A Study of Beef Flavour

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Table IV

Volatile components of beef flavour

Note: As far as possible systematic nomenclature has been used. This means that non-systematic names in the literature have been corrected.

Hydrocarbons

	Reference
n-butane	110
n-pentane	12, 110
n-hexane	12, 49, 110
n-heptane	12, 110
n-octane	12, 104, 110, 111
n-nonane	101, 104, 111
n-decane	101, 104, 111
n-undecane	101, 104, 111
n-dodecane	49, 104, 111
n-tridecane	101, 104, 111
n-tetradecane	101, 104, 111
n-pentadecane	49, 101, 104, 111
n-hexadecane	49, 101, 104, 111
n-heptadecane	101, 104, 111
n-octadecane	49, 101, 104, 111
n-nonadecane	104, 111
n-eicosane	104, 111
n-henеicosane	104, 111
n-docosane	104, 111
n-tricosane	104, 111
n-tetracosane	104, 111
n-pentacosane	104, 111
2-methylbutane	63
6(?)-methyltetradecane	101
undec-1-ene	49
tetradec-1-ene	111
pentadec-1-ene	49
hexadec-1-ene	111
octadec-1-ene	111
non-3-yne	12
benzene	12, 49, 101, 104, 111
toluene	12, 49, 101
n-propylbenzene	12
isopropylbenzene (cumene)	109, 111
n-butylbenzene	101
isobutylbenzene	12

Hydrocarbons (cont.)

	Reference
o-xylene	12, 101, 104, 111
m-xylene	12, 104, 111
p-xylene	12, 101
a diethylbenzene	101
1-ethyl-2-methylbenzene	12
1-ethyl-3-methylbenzene	12
1-ethyl-4-methylbenzene	12
1-ethyl-2-n-propylbenzene	12
1-ethyl-3-n-propylbenzene	12
1,2,3-trimethylbenzene	12, 101
1,2,4-trimethylbenzene	12
1,3,5-trimethylbenzene (mesitylene)	12, 101
Alkylbenzenes, M.wts 134, 148, 148, 162, 162	104
styrene	12
indene	12
a terpene (not necessarily hydrocarbon)	12

Alcohols

	Reference
methanol	12, 112
ethanol	49, 95, 104, 111, 113
propan-1-ol	49, 101
propan-2-ol	95
butan-1-ol	12, 49, 95, 101, 104, 111
butan-2-ol	95, 104, 111
pentan-1-ol	12, 49, 95, 101, 104, 111
hexan-1-ol	12, 95, 101, 104, 111
heptan-1-ol	95, 104, 111
heptan-2-ol	101, 105
heptan-3-ol	101, 105
heptan-4-ol	101
octan-1-ol	49, 95, 101
octan-3-ol	101, 105
octan-4-ol	101, 105
nonan-1-ol	105
decan-1-ol	105
undecan-1-ol	105
dodecan-1-ol	31
2-methylpropan-1-ol	49
3-methylbutan-1-ol	49, 95, 104, 111
2,3-butanediol	101
pent-1-en-3-ol	12
hex-2-en-1-ol	49
oct-1-en-3-ol	12, 49, 104, 111
oct-2-en-1-ol	101
phenol	101, 111

Alcohols (cont.)

	Reference
2-phenylethanol	104, 111
benzyl alcohol	12, 101
p-cresol	104
o-hydroxyacetophenone	103
a vinyl guaiacol	101
2,6-di-t-butyl-p-hydroxytoluene (B.H.T.)†	49

Aldehydes

	Reference
formaldehyde	55, 56, 63
acetaldehyde	12, 55, 56, 63, 112, 113
propanal	12, 95, 113
butanal	12
pentanal	12, 49, 95, 101, 104, 111
hexanal	49, 56, 95, 101, 104, 111
heptanal	49, 95, 101, 104, 111
octanal	49, 95, 101, 104, 111
nonanal	49, 56, 95, 101, 104, 111
decanal	12, 101, 111
undecanal	95, 101
dodecanal	101
tridecanal	111
tetradecanal	101
pentadecanal	101
hexadecanal	101
heptadecanal	101
2-methylpropanal	12, 63, 107
2-methylbutanal	12, 13, 107
3-methylbutanal	49, 95, 100, 101, 104
prop-2-enal	107
but-2-enal (crotonal)	107
hex-2-enal	101
oct-2-enal	49, 104, 111
non-2-enal	101, 104, 111
dec-2-enal	101, 104, 111
undec-2-enal	101, 111
dodec-2-enal	101
tridec-2-enal	101
*octa-2,4-dienal	101
nona-2,4-dienal	101
deca-2,4-dienal	101, 104, 112
undeca-2,4-dienal	101
dodeca-2,4-dienal	49

† see appendix to Table
* Tentative identification

Aldehydes (cont.)

	Reference
*6-methyl-hepta-2-enal	107
glyoxal	107
pyruvaldehyde	107
2-oxopropanal	107
benzaldehyde	49, 101
*3-methylbenzaldehyde (possibly 2-methyl)	49
phenylacetaldehyde	95, 101, 111
a methylcinnamaldehyde	101

Ketones

	Reference
acetone	12, 55, 56, 58, 89, 92, 113
butanone	12, 13, 83, 95
pentan-2-one	12
pentan-3-one	12
heptan-2-one	12
hexan-2-one	12
octan-2-one	12
octan-3-one	12
octan-4-one	49
nonan-2-one	12
nonan-3-one	49
nonan-4-one	12
decan-2-one	12
undecan-2-one	101, 111
dodecan-2-one	101, 111
dodecan-3-one	49
tridecan-2-one	101, 104, 111
pentadecan-2-one	101, 104, 111
hexadecan-2-one	111
heptadecan-2-one	101, 104, 111
3-methylbutanone	114
4-methylpentan-2-one	107
3-hydroxybutanone (acetoin)	31, 49, 95, 101, 104, 111
6-methylhept-5-ene-2-one	12
butane-2,3-dione (diacetyl)	12, 49, 89, 101, 110
pentan-2,3-dione	13, 101
octan-2,3-dione	101
acetophenone	105
a methylcyclopentanone	114
2-methyl-3-oxalanone (sic)	12

* Tentative identification

Carboxylic acids

	Reference
formic acid	89
acetic acid	31, 89, 101
propanoic acid	31, 49, 89
butanoic acid	31, 49, 73, 101
pentanoic acid	31
hexanoic acid	31, 49
2-methylpropanoic acid	31, 89, 113
2-methylpentanoic acid	31
4-methylpentanoic acid	31
lactic acid	31, 89
benzoic acid	101

Lactones

	Reference
4-hydroxybutanoic acid, lactone	101
4-hydroxypentanoic acid, lactone	49
4-hydroxyhexanoic acid, lactone	101, 111
4-hydroxyheptanoic acid, lactone	101, 102, 111
4-hydroxyoctanoic acid, lactone	101, 102, 111
4-hydroxynonanoic acid, lactone	101, 111
4-hydroxydecanoic acid, lactone	101, 102, 104, 111
4-hydroxydodecanoic acid, lactone	102, 104, 111
4-hydroxytridecanoic acid, lactone	102
4-hydroxytetradecanoic acid, lactone	102, 111
4-hyproxypentanoic acid, lactone	102
4-hydroxyhexadecanoic acid, lactone	102
5-hydroxypentanoic acid, lactone	101
5-hydroxyhexanoic acid, lactone	102
5-hydroxyheptanoic acid, lactone	101
5-hydroxyoctanoic acid, lactone	101
5-hydroxynonanoic acid, lactone	101
5-hydroxydecanoic acid, lactone	101, 102, 111
5-hydroxydodecanoic acid, lactone	101, 102, 111
5-hydroxytridecanoic acid, lactone	102
5-hydroxytetradecanoic acid, lactone	101, 102, 111
5-hydroxypentadecanoic acid, lactone	102
5-hydroxyhexadecanoic acid, lactone	102
a 4-hydroxymethylbutanoic acid, lactone	101

Esters

	Reference
methyl formate	92
ethyl formate	104, 111
methyl acetate	12
ethyl acetate	12, 49, 104, 111
ethyl butyrate	12
acetol acetate	13

Ethers

	Reference
dipentyl ether	49
dihexyl ether	33
n-butyl(2-hydroxyethyl) ether	101

Amines

ammonia	55, 56, 89
methylamine	55, 56

Chlorine containing compounds †

chloroform	104, 111
a tetrachlorobenzene	111
hexachlorobenzene	111

Sulphur compounds

(see also Thiophens and miscellaneous heterocyclic compounds)

hydrogen sulphide	12, 55, 89, 92, 112, 113
carbonyl sulphide	12
ethylene sulphide (thiran)	12
propylene sulphide (thetin)	12
dimethyl sulphide	12, 106
ethyl methyl sulphide	12
*methyl propyl sulphide	49
*allyl methyl sulphide	49
diallyl sulphide	49
carbon disulphide	12
dimethyl disulphide	12, 89, 101, 106
diethyl disulphide	106
ethyl methyl disulphide	106
methyl vinyl disulphide	106
dimethyl trisulphide	12
3-(methylthio)propanal (methional)†	100, 103
prop-2-enylthiomethane	33
prop-2-enylthioprop-2-ene	33
1,1-bis-(methylthio)methane	12
1,1-bis-(methylthio)ethane	106
methylthioacetate	106
dimethyl sulphone	101
methanethiol	55, 58, 112, 113

† see appendix to Table
* Tentative identification

Sulphur compounds (cont.)

	Reference
ethanethiol	58, 92, 112, 113
propanethiol	31
butan-1-thiol	31
2-methylpropan-1-thiol	106
1-(methylthio)ethanethiol †	100
naphthalene thiol	106

Furan derivatives

furan	12, 13
2-methylfuran	12
3-methylfuran	12
2-n-propylfuran	12
2-n-butylfuran	12
2-n-pentylfuran	12, 33, 101
2-n-hexylfuran	12, 101
2-n-heptylfuran	101
2-n-octylfuran	101
2,5-dimethylfuran	12, 13
2-acetylfuran	105
a hex-2-enylfuran	12
2-methylpropenylfuran (sic)	12
furfural	100, 111
5-methylthio-2-furfural †	49
a furfuryl alcohol	111
2-furfuryl methyl ketone	105
2-methyltetrahydrofuran-3-one †	49
4-hydroxy-5-methyl-3(2H)-furanone	31
4-hydroxy-2,5-dimethyl-3(2H)-furanone	31

Thiophens

thiophen	106, 115
2-methylthiophen	106, 115
3-methylthiophen	12
2-ethylthiophen	106
2-n-butylthiophen	106
2-n-pentylthiophen	12, 106
2-n-octylthiophen	106
a n-tetradecylthiophen	106
2-formylthiophen	12, 33
2-acetylthiophen	106
3-acetylthiophen	106

† see appendix to Table

Thiophens (cont.)

	Reference
thiophen-2-carboxaldehyde †	49, 106
thiophen-3-carboxaldehyde	106
*2,3-dimethylthiophen	12
*2,5-dimethylthiophen	12
2-acetyl-5-methylthiophen	106
2-(hydroxymethyl)thiophen	106
5-methyl-2-thiophencarboxaldehyde	106
2,5-dimethyl-3-thiophencarboxaldehyde	106
tetrahydrothiophen-3-one	106
2-methyltetrahydrothiophen-3-one	106
2-thienylpropanone	106
2-thienylacrolein	106
2-methyl-5-thienylpropanone	106

Pyrroles

2-acetylpyrrole	111
2-acetyl-N-methylpyrrole	105

Pyridines, Pyrazines and Quinoxalines

2-ethylpyridine	103
2-n-pentylpyridine	103
pyrazine	24
methylpyrazine	24, 103
ethylpyrazine	24, 32, 104
acetylpyrazine	24
vinylpyrazine	24
*isopropenylpyrazine	24
2,3-dimethylpyrazine	24, 103
2,5-dimethylpyrazine	24, 32, 103
2,6-dimethylpyrazine	24, 32, 103
*a methylpropylpyrazine	32
*2-methyl-6-vinylpyrazine	24
2-methyl-5-propenylpyrazine	24, 41
2,6-diethylpyrazine	24, 32, 104, 111
2-ethyl-3-methylpyrazine	32, 104
2-ethyl-5-methylpyrazine	24, 32, 103
2-ethyl-6-methylpyrazine	24, 32
5-acetyl-2-methylpyrazine	24
5-acetyl-2-ethylpyrazine	24
2,3,5-trimethylpyrazine	104
3,3,5-trimethylpyrazine	104
2,3-dimethyl-5-ethylpyrazine	24, 32

† see appendix to Table
* Tentative identification

Pyridines, Pyrazines and Quinoxalines (cont.)

	Reference
2,5-dimethyl-3-ethylpyrazine	32, 103
3,5-dimethyl-2-ethylpyrazine	24, 32
3,5-dimethyl-2-n-propylpyrazine	32
2,3-diethyl-5-methylpyrazine	32
2,5-diethyl-3-methylpyrazine	103
2,6-diethyl-3-methylpyrazine	24, 32
3,5-diethyl-2-methylpyrazine	24
a tetramethylpyrazine	24, 32, 103
3,6-diethyl-2,5-dimethylpyrazine	24
pyrazinylpropanone	24
cyclopentapyrazine	24
2-methylcyclopentapyrazine	24
5-methylcyclopentapyrazine	24
2,(3),5-dimethylcyclopentapyrazine	24
5,6,7,8-tetrahydroquinoxaline	24
2-methyl-5,6,7,8-tetrahydroquinoxaline	24

Miscellaneous heterocyclic compounds

thiazole	106
2-methylthiazole	106
4-methylthiazole	106
2-acetylthiazole	99, 106
2,4-dimethylthiazole	106
4-ethyl-2-methylthiazole	106
5-ethyl-4-methylthiazole	106
2,4,5-trimethylthiazole	106
2,4-dimethyl-5-vinylthiazole	106
benzothiazole	101, 105, 106
3,5-dimethyl-1,2,4-trithiolane † (cis and trans)	12, 49, 100, 106
5,6-dihydro-2,4,6-trimethyl-1,3,5-dithiazine (thialdine)†	100, 106
2,4,5-trimethyl-s-trithiane (trithioacetaldehyde)	106
2,2,4,4,6,6-hexamethyl-s-trithiane (trithioacetone)	106
2,4,5-trimethyl-3-oxazoline	49

† see appendix to Table

Appendix to Table

2,6-di-t-butyl-p-hydroxytoluene (BHT)

It is unlikely that this is a part of the natural beef aroma complex, but almost certainly derives from animal feed, being a well known antioxidant

chlorine containing compounds

These compounds are almost certainly contaminants, possibly from pesticide residues in the meat, and are not normally considered natural components of any food flavour

3-(methylthio)propanal (methional)

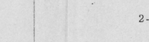
$CH_3 S CH_2 CH_2 CHO$

1-(methylthio)ethanethiol

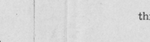
$CH_3 S CH(SH) CH_3$

5-methylthio-2-furfural

2-methyltetrahydrofuran-3-one

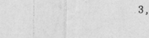


thiophen-2-carboxaldehyde

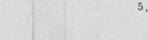


2-acetylthiazole

3,5-dimethyl-1,2,4-trithiolane



5,6-dihydro-2,4,6-trimethyl-1,3,5-dithiazine (thialdine)



2,4,5-trimethyl-3-oxazoline

Table XIV

Volatile components of beef aroma extract (Sample S)

Peak Number	Relative retention time min.	Internal Standard	Identity by GC/MS	Certainty of MS identity	MS Code	Relative to of reference compound	Aroma as eluted from column
1S	2.6	← solvent impurities					
2S	3.1		2-methylbutane				
3S	4.0		2-methylpentane	**	S2-1.1, S3-2.1	3.9	
4S	4.6		n-hexane	***	S2-1.2, S3-2.2		
5S	4.9						
6S	5.6		2-methylhexane	**	S3-2.3	5.5	sweet, sickly, sulphurous quality
7S	5.8		dimethylbutene	*	S3-2.4		pleasant, sweet
8S	6.5		hex-1-ene	***	S3-2.5		dull, cardboard
9S	7.1	n-heptane at retn. 7.1	n-heptane	***	S2-1.5, S3-2.6	7.1	cooked meat
10S	7.6						
11S	9.2		hept-1-ene	***	S2-1.6, S3-2.8		sulphide like
12S	10.0		2-methylheptane	***	S3-2.9	9.7	solvent like
13S	10.6						faint garlic, vegetable broth
14S	12.4		n-octane	***	S2-1.8, S3-2.12		meaty
15S	14.3		acetone	**	S2-1.9	14.3 E.M.S	dull, meat broth like
16S	16.2		oct-1-ene (+ethylmethyl sulphide?)	***	S2-1.10,	15.4	strong garlic, onions
17S	17.8						faint, pleasant, animal like
18S	18.7		2-methylfuran	*	S3-2.16	18.6	pleasant, slightly sulphurous
19S	19.0						meaty
20S	20.5	n-nonane at retn. 20.5	n-nonane	***	S2-1.13, S3-2.17	20.5	strong, sour, harsh, burnt, metallic, unpleasant
21S	21.2		butanone	***	S2-1.15, S3-2.18	21.2	grassy, sweet, strong, sickly, doughy
22S	22.3						meaty, sulphurous
23S	23.3		non-1-ene	***	S2-1.17, S3-2.21		grassy, strong, like plastic, rancid, oniony
24S	24.5		benzene	***	S2-1.19, S3-2.23	24.5	grassy, leaves, hay, solvent like
25S	25.4		2-methylthiophen?	*	S3-2.24		very strong garlic, sweet
26S	26.3		2-pentanone	***	S2-1.20, S3-2.25	26.3	sickly, buttery, meaty, pleasant, sweet
27S	26.9		n-decane	***	S2-1.22, S3-2.26		strong, pleasant, sweet, solvent like, pungent
28S	27.6						
29S	28.5						strong, sweet, sickly, oily, pleasant, fruity, buttery
30S	29.5						sweet, meaty, strong, earthy
31S	30.5		dec-1-ene	***	S2-1.25,		strong cardboard, plastic
31aS	31.5						
32S	32.3		toluene	***	S1-07, S2-1.27, S3-2.30	32.3	strong, fruity, becoming dank, like batter
32aS	32.8						
33S	33.3						rancid
34S	34.3						sour 'off', slightly burnt
35S	35.4						burnt
36S	36.4		n-undecane	***	S2-1.32, S3-2.32	36.4	strong, unpleasant
37S	37.3		dimethyldisulphide	***	S2-1.32, S3-2.33	37.3	very strong sulphurous, onion, garlic
38S	39.9	n-tridecane at retn. 68.0	n-hexanal	**	S1-09, S2-1.34 S3-2.35	40.1	strong rancid, foul
39S	42.1		undec-1-ene	***	S2-1.35, S3-2.38		unpleasant, old meat
40S	43.5		p-xylene	***	S1-010, S2-1.36, S3-2.39	43.4	fruity, solvent like,
41S	45.6		undec-4-ene	*	S3-2.40		
42S	46.5						sweet, sulphurous, faint meaty
43S	48.2						rancid, rotting vegetables
44S	50.2		n-dodecane	***	S2-1.37, S3-2.44		
45S	52.0		o-xylene	***	S2-1.39, S3-2.46	52.1	sweetish
46S	53.4		a methylpyridine (prob. 2-methyl)	***	S1-013, S3-2.47	54.1	
47S	55.9		n-propylbenzene	***	S2-1.40, S3-2.48		
48S	57.3						
49S	59.8						
50S	62.0		dodec-1-ene	***	S2-1.42, S3-2.50		medicinal
51S	66.0		styrene	***	S1-016, S2-1.43, S3-2.51		
52S	67.2		diethylsulphide ??			67.2	very strong sulphide, sweet, pleasant
53S	68.0	n-tridecane at retn. 68.0	n-tridecane	***	S2-1.44, S3-2.52		
54S	69.9		a C_5 pyridine, prob. n-propyl	**	S2-1.45, S3-2.53		background smell, sweet, like green peppers, slightly rubbery
55S	70.6						
56S	71.7						
57S	72.8		tridec-1-ene	***	S3-2.54		
58S	73.4		n-butylbenzene	***	S2-1.49, S3-2.55		
59S	74.6		a dimethylpyrazine prob. 2,6-	**	S1-019		
60S	75.6		ethylpyrazine	**	S2-1.49		
61S	77.0						
62S	77.8						
63S	80.8		n-tetradecane	***	S2-1.51, S3-2.60, S4-1.3		
64S	82.1						
65S	83.3		a C_5 satd. subst. pyrrole, prob. N-n-pentyl-	***	S1-022, S2-1.52, S4-1.4		
66S	85.8		indan	***	S3-2.61, S4-1.6		
66aS	87.1						
67S	88.1		tetradec-1-ene	***	S2-1.54, S3-2.62		
68S	90.6		a dimethylethyl-pyrazine, prob. 2,3-dimethyl-5-ethyl	***	S1-024	Lit. 90.3	
69S	93.4		a dimethylpyridine, prob. 3,4-	***	S1-025		
70S	97.2	n-pentadecane at retn. 97.2	n-pentadecane	***	S2-1.57 S4-1.11	97.2	
71S	100.0						
72S	103.0		pyrrole	***	S1-026, S2-1.60, S4-1.12	102.8	
72aS	106.0						
73S	107.0		pentadec-1-ene	***	S2-1.61, S4-1.14		
74S	110.0						
75S	112.0		a methylpyrrole, prob. 2-methyl	***	S1-029, S4-1.16		
76S	115.0						
77S	116.0						
78S	120.5		n-hexadecane	***	S2-1.63, S3-2.71, S4-1.18		
79S	123.5						
80S	127.5		hexadec-1-ene	***	S2-1.65, S4-1.20		
81S	130.0						
82S	134.5						
83S	139.0	n-heptadecane at retn. 137.0	a dimethylpyrrole, 2,4- or 2,5-	***	S1-032, S4-1.21		
84S	144.0						
85S	147.0						
86S	148.5		a C_5 satd. subst. pyrazine, possibly methylisobutyl	*	S1-038		
87S	152.5						
88S	157.0		n-heptadecane	***	S4-1.25	157.0	
89S	161.0		phenol	*	S4-1.26	160.0	
90S	166.0		m-tolunitrile	***	S1-044	166.0	
91S	168.0		heptadec-1-ene	***	S4-1.28		
92S	177.5						
93S	181.0						
94S	186.0						
95S	195.0						
96S	201.0						
97S	208.0						
98S	217.5						
99S	224.0						
100S	229.5						
101S	236.0						
102S	245.0						
103S	258.5						

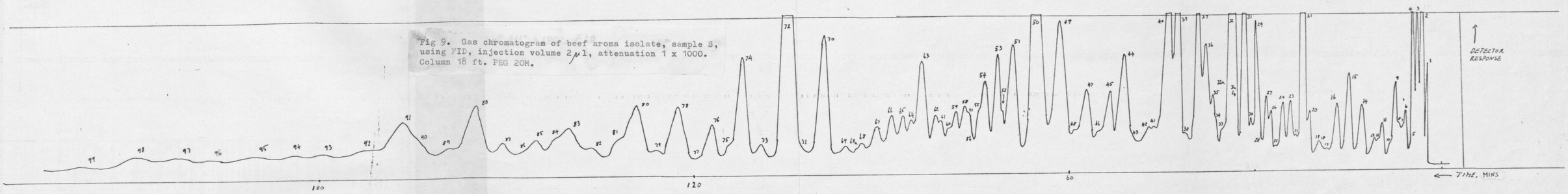


Fig 9. Gas chromatogram of beef aroma isolate, sample S, using FID, injection volume 2 µl, attenuation 1 x 1000. Column 18 ft. PEG 20M.

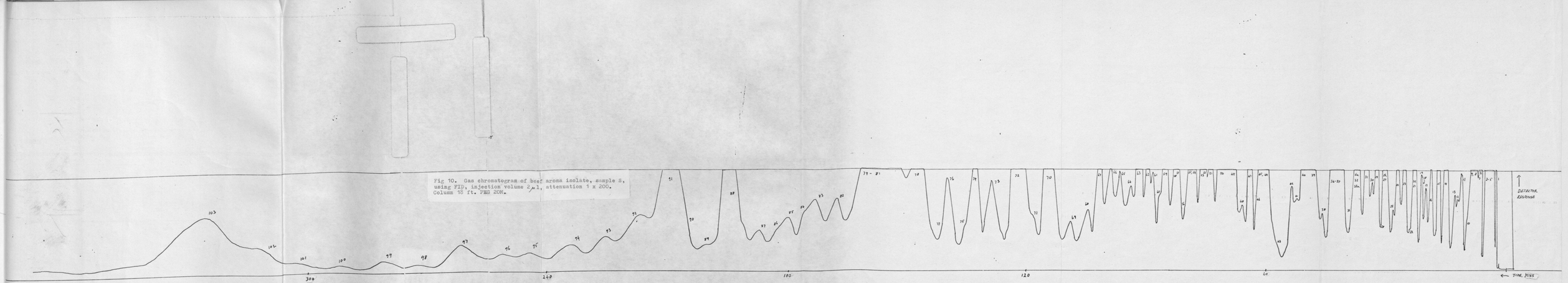


Fig 10. Gas chromatogram of beef aroma isolate, sample S, using FID, injection volume 2 µl, attenuation 1 x 200. Column 18 ft. PEG 20M.

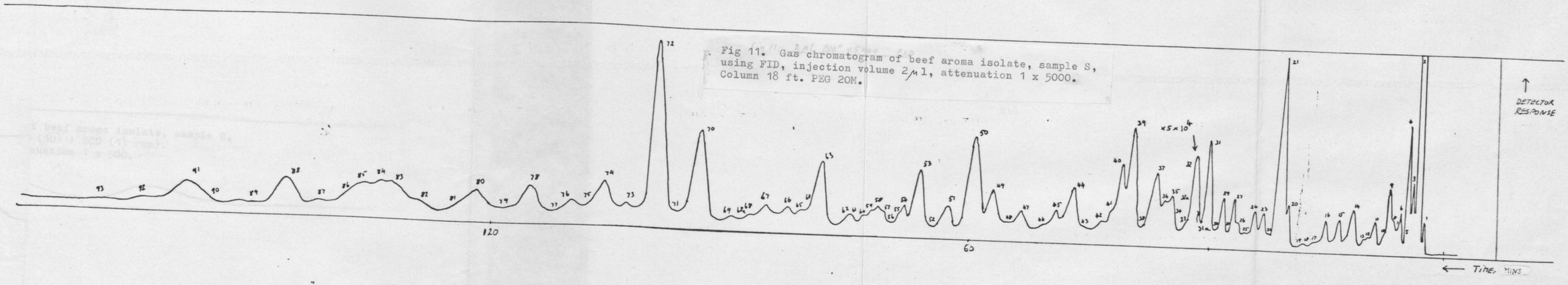


Fig 11. Gas chromatogram of beef aroma isolate, sample S, using FID, injection volume 2 µl, attenuation 1 x 5000. Column 18 ft. PEG 20M.

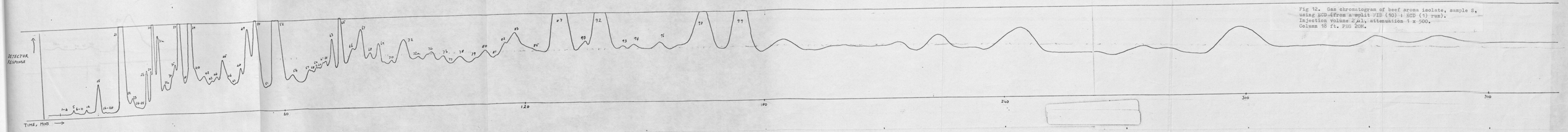


Fig 12. Gas chromatogram of beef aroma isolate, sample S, using ECD-(from a split FID (10) : ECD (1) run). Injection volume 2 µl, attenuation 1 x 500. Column 18 ft. PEG 20M.

Table XX

Volatile components of beef aroma extract - sample W

Peak Number	Relative retention time min.	Identity	Certainty of identity from mass spec.	Internal Standard	Relative to reference compound	MS Code
1W	5.7	(dimethylbutene)	*	n-heptane at retn. 7.1		S3-2.4
2W	6.4	(hex-1-ene)	**			S3-2.5
3W	7.1	(n-heptane)	***			S2-1.5, S3-2.6
4W	8.5					
5W	9.3	(hept-1-ene)	***			S3-2.8
6W	10.5	(2-methylheptane)	***			S3-2.9
7W	12.8	(n-octane)	***			S2-1.8, S3-2.12
8W	14.3	acetone	***		14.3	S2-1.9, W1-1
9W	16.5	(oct-1-ene (+ethylmethyl-sulphide??))	***	benzene at retn. 24.5	15.4	S2-1.10, S3-2.14
10W	18.0					
11W	18.5	(2-methylfuran)	*		18.6	S3-2.16
12W	18.8					
13W	20.5	(n-nonane)	***		20.5	S2-1.13, S3-2.17
14W	21.2	butanone	***		21.2	S2-1.15, S3-2.18 W3-1a
15W	22.4	3-methylbutanal x	**		22.5	W3-2
16W	23.7	(non-1-ene)	***			S2-1.17, S3-2.12
17W	24.5	benzene + 2-ethylfuran x	***		benzene 24.5	S2-1.19, S3-2.23 W3-3
18W	25.4	(2-methylthiophen??)	*	benzene at retn. 24.5		S3-2.24
19W	26.4	(2-pentanone)	***		26.3	S2-1.20, S3-2.25
20W	26.9	n-decane + a methylbutanol x	***			S2-1.22, S3-2.26 W3-4, 4a, 4b
21W	28.5					
22W	29.0	tetrachloroethane x	***			W3-5
23W	30.6	(dec-1-ene)				
24W	32.1	toluene	***		32.3	S1-07, S2-1.27, S3-2.30, W1-6, W3-6
25W	33.3					
26W	34.9					
27W	36.4	n-undecane + unknown (prob. N-containing) x	***	n-undecane at retn. 36.4		S2-1.32, S3-2.32, W1-7, W3-7
28W	37.4	dimethyldisulphide	***		37.3	W3-7
29W	39.5	(n-hexanal)	**		40.0	S1-09, S2-1.34, S3-2.35
30W	41.0	(undec-1-ene)	***			S2-1.35, S3-2.38
31W	42.8	p-xylene	***		43.4	S1-010, S2-1.36, S3-2.39, W1-8, W3-8
32W	43.4					
33W	44.6					
34W	45.6	(undec-4-ene)	*	n-undecane at retn. 46.4		S3-2.40
35W	46.8					
36W	48.0					
37W	50.1	unknown - not dodecane at 50.2				
38W	52.0	o-xylene	***			S2-1.34, S3-2.46, W1-10, W3-10
39W	52.9	(a methylpyridine, prob. 2-methyl)	***	propylbenzene at retn. 53.9	54.0	S1-013, S3-2.47
40W	55.9	n-propylbenzene + 2-n-pentylfuran x	***		prop. benzene 56.0	S2-1.40, S3-2.48 W3-11, W4-6
41W	57.5					
42W	60.5	a C_3 benzene x	***	styrene at retn. 66.0		W3-11c
43W	63.4	(dodedec-1-ene)	***			S2-1.42, S3-2.50
44W	66.0	styrene	***			S1-016, S2-1.43, S3-2.51, W3-12
45W	68.5	methylpyrazine x	*		68.3	W3-12a
46W	69.3	a C_3 pyridine, prob. n-propyl	**			S2-1.45, S3-2.53 W3-13
47W	70.5					
48W	72.8	(tridec-1-ene)	***	2,6-dimethyl-pyrazine at retn. 74.6		S3-2.54
49W	74.6	a dimethylpyrazine, prob. 2,6-	***		74.5	W1-15, W3-13a, W4-9
50W	75.7	ethylpyrazine	**		75.6	S1-019, W3-14
51W	76.2					
52W	76.5					
53W	77.5					
54W	78.2					
55W	79.3			n-pentadecane at retn. 97.2		
56W	80.5	(n-tetradecane) + unknown x	***			S2-1.51, S3-2.60, S4-1.3, W3-A
57W	81.5	an ethylmethylpyrazine prob. 2-ethyl-6-methyl x	***			W1-16, W3-B
58W	81.7	an ethylmethylpyrazine prob. 2-ethyl-5-methyl x	***			W3-C
59W	83.3	a trimethylpyrazine prob. 2,3,5- x	***			W3-D
60W	83.8	a long chain hydrocarbon x	***			W3-E
61W	87.4	(tetradec-1-ene) + unknown x	***			S2-1.54, S3-2.62, W3-F
62W	90.7	a dimethylethylpyrazine	***			S1-024, W4-15, W3-G
63W	91.6					
64W	93.3	a dimethylethylpyrazine prob. 2,5-dimethyl-3-ethyl-	***			W1-19, W3-Ga
65W	94.3					
66W	97.2	n-pentadecane	***		97.2	S2-1.57, S4-1.11, W1-21, W3-I
67W	97.8					
68W	100.0					
69W	102.5	(pyrrole)	***		102.8	S1-020, S2-1.60, S4-1.12
70W	106.0					
71W	107.0	benzaldehyde x	***		106.5	W1-23, W3-L, W4-17
72W	109.0	nonanol x	***		108.0	W3-M
73W	113.0	(a methylpyrrole, prob. 2-methyl)	***			S1-029, S4-1.16
74W	116.0					
75W	119.0					
76W	122.0	n-hexadecane	***			S2-1.63, S3-2.71, S4-1.20, W1-25, W3-P
77W	130.0	(hexadec-1-ene)	**	n-heptadecane at retn. 157.0		S1-034, S2-1.65, S4-1.20, W3-S
78W	136.5					
79W	138.5					
80W	142.5	(a dimethylpyrrole, 2,4- or 2,5-)	*			S1-036
81W	147.5	a C_5 satd. subst. pyrazine poss. methyl isobutyl x	*			S1-038
82W	157.0	n-heptadecane	***			S4-1.25, W3-U
83W	161.0	(phenol)	*			S4-1.26
84W	166.0	(m-tolunitrile)	**		166.0	S1-044
85W	169.5					
86W	179.0					
87W	187.5	ethylbenzaldehyde x	***			W3-V
88W	191.5					
89W	201.0	C_{20} branched alkene, MW 280 (branched at C_{13}) x	***			W3-1st
90W	208.0					
91W	218.0					
92W	226.5					
93W	237.0					
94W	245.0					
95W	258.0	C_{20} branched alkene, MW 280 (branched at C_{13}) x	***			W3-2nd
96W	266.0					
97W	278.0					
98W	285.0					
99W	300.0					
100W	311.0	C_{20} branched alkadiene, MW 278 (branched at C_{13}) x	***			W3-3rd
101W	345.0					
102W	356.0					

NB Brackets denote compounds identified in sample S (Section I) only, correlated by relative retention time.

x denotes those compounds identified in sample W only

Table XX

Volatile components of beef aroma extract - sample W

Peak Number	Relative retention time min.	Identity	Certainty of identity from mass spec.	Internal Standard	Relative t_R of reference compound	MS Code
1W	5.7	(dimethylbutene)	*	n-heptane at retn. 7.1		S3-2.4
2W	6.4	(hex-1-ene)	**			S3-2.5
3W	7.1	(n-heptane)	***			S2-1.5, S3-2.6
4W	8.5					
5W	9.3	(hept-1-ene)	***			S3-2.8
6W	10.5	(2-methylheptane)	***			S3-2.9
7W	12.8	(n-octane)	***			S2-1.8, S3-2.12
8W	14.3	acetone	***	benzene at retn. 24.5	14.3	S2-1.9, W1-1
9W	16.5	(oct-1-ene (+ethylmethyl-sulphide??))	***		15.4	S2-1.10, S3-2.14
10W	18.0					
11W	18.5	(2-methylfuran)	*		18.6	S3-2.16
12W	18.8					
13W	20.5	(n-nonane)	***		20.5	S2-1.13, S3-2.17
14W	21.2	butanone	***		21.2	S2-1.15, S3-2.18 W3-1a
15W	22.4	3-methylbutanal x	**	benzene at retn. 24.5	22.5	W3-2
16W	23.7	(non-1-ene)	***			S2-1.17, S3-2.12
17W	24.5	benzene + 2-ethylfuran x	***		benzene 24.5	S2-1.19, S3-2.23 W3-3
18W	25.4	(2-methylthiophen??)	*			S3-2.24
19W	26.4	(2-pentanone)	***		26.3	S2-1.20, S3-2.25
20W	26.9	n-decane + a methylbutanol x	***			S2-1.22, S3-2.26 W3-4, 4a, 4b
21W	28.5					
22W	29.0	tetrachloroethane x	***			W3-5
23W	30.6	(dec-1-ene)				
24W	32.1	toluene	***		32.3	S1-07, S2-1.27, S3-2.30, W1-6, W3-6
25W	33.3					
26W	34.9					
27W	36.4	n-undecane + unknown x (prob. N-containing)	***	n-undecane at retn. 36.4		S2-1.32, S3-2.32, W1-7, W3-7
28W	37.4	dimethyldisulphide	***		37.3	W3-7
29W	39.5	(n-hexanal)	**		40.0	S1-09, S2-1.34, S3-2.35
30W	41.0	(undec-1-ene)	***			S2-1.35, S3-2.38
31W	42.8	p-xylene	***		43.4	S1-010, S2-1.36, S3-2.39, W1-8, W3-8
32W	43.4					
33W	44.6					
34W	45.6	(undec-4-ene)	*	n-undecane at retn. 46.4		S3-2.40
35W	46.8					
36W	48.0					
37W	50.1	unknown - not dodecane at 50.2				
38W	52.0	o-xylene	***			S2-1.34, S3-2.46, W1-10, W3-10
39W	52.9	(a methylpyridine, prob. 2-methyl)	***	propylbenzene at retn. 55.9	54.0	S1-013, S3-2.47
40W	55.9	n-propylbenzene + 2-n-pentylfuran x	***		prop. benzene 56.0	S2-1.40, S3-2.48 W3-11, W4-6
41W	57.5					
42W	60.5	a C_3 benzene x	***			W3-11c
43W	63.4	(dodedec-1-ene)	***			S2-1.42, S3-2.50
44W	66.0	styrene	***	styrene at retn. 66.0		S1-016, S2-1.43, S3-2.51, W3-12
45W	68.5	methylpyrazine x	*		68.3	W3-12a
46W	69.3	a C_3 pyridine, prob. n-propyl	**			S2-1.45, S3-2.53 W3-13
47W	70.5					
48W	72.8	(tridec-1-ene)	***	2,6-dimethyl pyrazine at retn. 74.6		S3-2.54
49W	74.6	a dimethylpyrazine, prob. 2,6-	***		74.5	W1-15, W3-13a, W4-9
50W	75.7	ethylpyrazine	**		75.6	S1-019, W3-14
51W	76.2					
52W	76.5					
53W	77.5					
54W	78.2					
55W	79.3					
56W	80.5	(n-tetradecane) + unknown x	***	n-pentadecane at retn. 97.2		S2-1.51, S3-2.60, S4-1.3, W3-A
57W	81.5	an ethylmethylpyrazine x prob. 2-ethyl-6-methyl	***			W1-16, W3-B
58W	81.7	an ethylmethylpyrazine x prob. 2-ethyl-5-methyl	***			W3-C
59W	83.3	a trimethylpyrazine x prob. 2,3,5-	***			W3-D
60W	83.8	a long chain hydrocarbon x	***			W3-E
61W	87.4	(tetradec-1-ene) + unknown x	***			S2-1.54, S3-2.62, W3-F
62W	90.7	a dimethylethylpyrazine	***			S1-024, W4-15, W3-G
63W	91.6					
64W	93.3	a dimethylethylpyrazine prob. 2,5-dimethyl-3-ethyl-	***			W1-19, W3-Ga
65W	94.3					
66W	97.2	n-pentadecane	***		97.2	S2-1.57, S4-1.11, W1-21, W3-I
67W	97.8					
68W	100.0					
69W	102.5	(pyrrole)	***		102.8	S1-020, S2-1.60, S4-1.12
70W	106.0					
71W	107.0	benzaldehyde x	***		106.5	W1-23, W3-L, W4-17
72W	109.0	nonanol x	***		108.0	W3-M
73W	113.0	(a methylpyrrole, prob. 2-methyl)	***			S1-029, S4-1.16
74W	116.0					
75W	119.0					
76W	122.0	n-hexadecane	***			S2-1.63, S3-2.71, S4-1.20, W1-25, W3-P
77W	130.0	(hexadec-1-ene)	**			S1-034, S2-1.65, S4-1.20, W3-S
78W	136.5					
79W	138.5					
80W	142.5	(a dimethylpyrrole, 2,4- or 2,5-)	*			S1-036
81W	147.5	a C_5 satd. subst. pyrazine poss. methyl isobutyl	*			S1-038
82W	157.0	n-heptadecane	***	n-heptadecane at retn. 157.0		S4-1.25, W3-U
83W	161.0	(phenol)	*			S4-1.26
84W	166.0	(m-tolunitrile)	**		166.0	S1-044
85W	169.5					
86W	179.0					
87W	187.5	ethylbenzaldehyde x	***			W3-V
88W	191.5					
89W	201.0	C_{20} branched alkene, MW 280 x (branched at C_{13})	***			W3-1st
90W	208.0					
91W	218.0					
92W	226.5					
93W	237.0					
94W	245.0					
95W	258.0	C_{20} branched alkene, MW 280 x (branched at C_{13})	***			W3-2nd
96W	266.0					
97W	278.0					
98W	285.0					
99W	300.0					
100W	311.0	C_{20} branched alkadiene, MW 278 x (branched at C_{13})	***			W3-3rd
101W	345.0					
102W	356.0					

NB Brackets denote compounds identified in sample S (Section I) only, correlated by relative retention time.

x denotes those compounds identified in sample W only

Table XXI

Absolute peak areas and PRAs of all peaks of all isolates

	Conventional Boiled Samples - Extraction Times						Conventional Roasted Samples - Extraction Times					
	B - 15 min		C - 30 min		D - 1 hour		F - 15 min		G - 30 min		H - 1 hour	
Peak	Area	PRA	Area	PRA	Area	PRA	Area	PRA	Area	PRA	Area	PRA
1W	-	-	-	-	440	0.50	-	-	310	1.75	326	0.50
2W	134	0.50	160	0.50	116	0.25	-	-	-	-	100	0.20
3W	-	-	255	0.75	765	1.00	62	0.50	35	0.20	110	0.20
4W	-	-	-	-	-	-	-	-	-	-	-	-
5W	-	-	15	0.05	54	0.05	-	-	-	-	-	-
6W	-	-	-	-	-	-	-	-	-	-	-	-
7W	190	0.50	293	0.75	925	1.25	110	1.00	112	0.75	325	0.50
8W	130	0.50	63	0.20	205	0.25	1000	8.50	310	1.75	830	1.50
9W	-	-	-	-	-	-	-	-	-	-	-	-
10W	-	-	50	0.10	-	-	-	-	-	-	-	-
11W	-	-	10	0.02	35	0.05	-	-	20	0.10	30	0.05
12W	-	-	-	-	-	-	-	-	-	-	-	-
13W	-	-	8	0.02	35	0.05	15	0.10	17	0.10	55	0.01
14W	50	0.10	49	0.10	74	0.10	64	0.50	30	0.20	212	0.50
15W	4800	15.00	1800	5.00	4600	6.00	2550	21.50	5350	31.50	6800	12.00
16W	-	-	-	-	-	-	-	-	-	-	70	0.10
17W	2000	6.25	1670	4.75	4640	6.00	456	3.75	1440	8.50	1020	1.75
18W	60	0.20	96	0.25	840	1.00	25	0.20	5	0.02	73	0.10
19W	-	-	-	-	-	-	15	0.10	-	-	-	-
20W	350	1.00	401	1.25	790	1.00	640	5.25	500	3.00	835	1.50
21W	-	-	-	-	-	-	10	0.10	-	-	-	-
22W	-	-	8	0.02	30	0.05	54	0.50	15	0.10	45	0.10
23W	45	0.10	35	0.10	225	0.25	45	0.25	100	0.50	334	0.50
24W	680	2.00	618	1.75	930	1.25	142	1.25	375	2.25	914	1.50
25W	-	-	-	-	48	0.05	-	-	120	0.75	150	0.25
26W	30	0.10	25	0.05	-	-	20	0.25	-	-	40	0.05
27W	2200	7.00	3200	9.00	6350	8.50	485	4.00	707	4.00	1950	3.50
28W	-	-	-	-	-	-	-	-	-	-	-	-
29W	70	0.25	114	0.25	275	0.50	-	-	-	-	170	0.25
30W	30	0.10	84	0.20	144	0.20	-	-	-	-	56	0.10
31W	900	2.75	1860	5.00	2900	3.75	35	0.25	30	0.20	466	0.75
32W	-	-	-	-	-	-	-	-	-	-	-	-
33W	-	-	-	-	-	-	-	-	-	-	35	0.05
34W	35	0.10	6	0.01	120	0.25	112	1.00	145	0.75	500	1.00
35W	50	0.20	123	0.25	195	0.25	-	-	-	-	-	-
36W	-	-	-	-	-	-	-	-	-	-	-	-
37W	1000	3.25	1120	3.25	2340	3.00	156	1.25	307	1.75	1240	2.00
38W	132	0.50	130	0.50	120	0.25	-	-	10	0.05	73	0.10
39W	-	-	-	-	-	-	32	0.25	10	0.05	75	0.10
40W	2300	7.50	4300	12.00	9250	12.00	285	2.50	310	1.75	4000	7.00
41W	-	-	10	0.05	-	-	-	-	-	-	-	-
42W	-	-	-	-	-	-	-	-	-	-	-	-
43W	-	-	-	-	54	0.05	-	-	-	-	-	-
44W	60	0.20	665	2.00	185	0.25	-	-	160	1.00	680	1.25
45W	-	-	-	-	-	-	-	-	-	-	-	-
46W	980	3.00	600	1.75	1320	1.75	45	0.50	50	0.25	50	0.10
47W	510	1.50	-	-	865	1.00	190	1.50	245	1.50	765	1.50
48W	-	-	-	-	-	-	-	-	-	-	-	-
49W	275	1.00	710	2.00	1150	1.50	320	2.50	60	0.25	275	0.50
50W	860	2.75	1800	5.00	2900	3.75	344	2.75	729	4.25	2834	5.00
51W	-	-	-	-	-	-	69	0.50	146	0.75	566	1.00
52W	-	-	28	0.10	-	-	56	0.50	120	0.75	320	0.50
53W	-	-	-	-	189	0.25	-	-	-	-	-	-
54W	-	-	320	0.10	-	-	52	0.50	-	-	50	0.10
55W	-	-	-	-	-	-	-	-	-	-	30	0.05
56W	-	-	-	-	-	-	-	-	-	-	-	-
57W	2200	7.00	1480	4.10	3120	4.00	350	3.00	620	3.50	1050	1.75
58W	-	-	-	-	-	-	170	1.50	300	1.75	900	1.50
59W	-	-	35	0.10	112	0.10	-	-	-	-	-	-
60W	70	0.25	6	0.01	-	-	492	4.00	540	3.25	1560	2.75
61W	2420	7.75	3500	10.00	6960	9.00	350	3.00	400	2.25	2150	3.75
62W	-	-	500	1.50	1520	2.00	150	1.25	200	1.25	800	1.50
63W	-	-	-	-	-	-	225	2.00	420	2.50	1400	2.50
64W	-	-	-	-	-	-	-	-	-	-	-	-
65W	130	0.50	-	-	495	0.50	144	1.25	196	1.25	1210	2.00
66W	66	0.20	325	1.00	345	0.50	50	0.50	10	0.05	215	0.50
67W	-	-	-	-	-	-	-	-	-	-	-	-
68W	130	0.50	90	0.25	77	0.10	140	1.25	120	0.75	480	0.75
69W	-	-	170	0.50	80	0.10	216	1.75	116	0.75	48	0.75
70W	-	-	52	0.10	-	-	-	-	-	-	-	-
71W	1640	5.25	1300	3.50	2700	3.50	650	5.50	750	4.50	2200	3.75
72W	-	-	-	-	-	-	-	-	-	-	-	-
73W	-	-	-	-	-	-	-	-	-	-	-	-
74W	50	0.20	-	-	-	-	-	-	-	-	-	-
75W	-	-	127	0.25	80	0.10	-	-	-	-	130	0.20
76W	720	2.25	1020	3.90	3580	4.75	-	-	75	0.50	525	1.00
77W	-	-	-	-	240	0.25	-	-	-	-	-	-
78W	-	-	-	-	-	-	-	-	-	-	305	0.50
79W	1220	3.75	1260	3.50	1920	2.50	-	-	-	-	3000	5.00
80W	-	-	-	-	-	-	-	-	-	-	-	-
81W	240	0.75	370	1.00	215	0.25	-	-	-	-	-	-
82W	-	-	125	0.50	1250	1.50	-	-	-	-	-	-
83W	50	0.20	-	-	-	-	-	-	-	-	-	-
84W	-	-	-	-	-	-	-	-	-	-	-	-
85W	300	1.00	640	1.75	-	-	-	-	-	-	-	-
86W	-	-	-	-	-	-	-	-	-	-	-	-
87W	990	3.00	720	2.00	1330	1.75	460	3.75	-	-	1880	3.25
88W	-	-	-	-	-	-	-	-	-	-	-	-
89W	2260	7.00	1670	4.75	5520	7.50	1180	10.00	1300	7.75	7100	12.50
90W	-	-	230	0.50	120	0.20	-	-	175	1.00	700	1.25
91W	-	-	185	0.50	350	0.50	-	-	-	-	-	-
92W	-	-	10	0.02	-	-	-	-	-	-	-	-
93W	-	-	-	-	-	-	-	-	-	-	-	-
94W	-	-	-	-	-	-	-	-	-	-	-	-
95W	1320	4.25	860	2.50	2180	3.00	-	-	-	-	400	7.00
96W	-	-	-	-	-	-	-	-	-	-	-	-
97W	-	-	-	-	-	-	-	-	-	-	-	-
98W	-	-	-	-	-	-	-	-	-	-	-	-
99W	-	-	-	-	-	-	-	-	-	-	-	-
100W	-	-	590	1.75	370	0.50	-	-	-	-	-	-
101W	-	-	-	-	-	-	-	-	-	-	-	-
102W	-	-	-	-	-	-	-	-	-	-	-	-
Total peak area	31677		35604		75674		11966		16990		57689	

Table XXI (cont.)

	Microwave Boiled Samples - Extraction Times								Microwave Roasted Samples - Extraction Times							
	I - 5 min		J - 15 min		K - 30 min		L - 1 hour		M - 5 min		N - 15 min		O - 30 min		P - 1 hour	
Peak	Area	PRA	Area	PRA	Area	PRA	Area	PRA	Area	PRA	Area	PRA	Area	PRA	Area	PRA
1W	-	-	185	0.75	790	1.75	1360	2.25	-	-	-	-	-	-	-	-
2W	126	0.75	197	1.00	175	0.50	127	0.20	-	-	10	0.05	-	-	-	-
3W	119	0.75	260	1.25	275	0.50	570	1.00	-	-	25	0.10	23	0.05	-	-
4W	-	-	-	-	20	0.05	-	-	-	-	-	-	-	-	-	-
5W	20	0.10	45	0.20	347	0.75	240	0.50	-	-	72	0.50	-	-	-	-
6W	-	-	12	0.05	12	0.02	-	-	-	-	-	-	-	-	-	-
7W	246	1.50	218	1.00	600	1.25	730	1.25	60	0.50	115	0.50	133	0.25	135	0.25
8W	210	1.25	330	1.50	65	0.10	227	0.50	286	1.75	330	1.75	830	2.00	875	2.00
9W	-	-	-	-	-	-	-	-	-	-	-	-	15	0.05	-	-
10W	-	-	-	-	-	-	-	-	35	0.25	35	0.20	7	0.01	-	-
11W	-	-	12	0.05	-	-	-	-	25	0.20	10	0.05	13	0.02	72	0.20
12W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13W	-	-	8	0.02	32	0.10	24	0.05	-	-	-	-	250	0.50	30	0.05
14W	-	-	40	0.25	28	0.05	96	0.25	580	3.75	338	1.75	20	0.05	36	0.10
15W	287	1.75	750	3.50	1120	2.50	6500	10.50	5700	36.50	7900	40.50	10400	27.00	12100	27.50
16W	-	-	-	-	-	-	-	-	660	4.25	-	-	150	0.50	-	-
17W	502	3.00	1830	8.50	1240	2.75	3200	5.00	80	0.50	865	5.00	360	1.00	250	0.50
18W	-	-	-	-	-	-	104	0.25	-	-	-	-	7	0.01	-	-
19W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	80	0.20
20W	240	1.50	250	1.25	530	1.25	784	1.25	2250	14.50	915	4.75	1090	2.75	410	1.00
21W	-	-	-	-	-	-	10	0.02	-	-	-	-	-	-	-	-
22W	129	0.75	33	0.10	114	0.25	100	0.25	374	2.50	80	0.50	96	0.25	480	1.00
23W	-	-	-	-	-	-	90	0.25	-	-	35	0.20	183	0.50	155	0.50
24W	254	1.50	318	1.50	1065	2.50	990	1.50	438	2.75	163	0.75	735	2.00	1370	3.00
25W	-	-	208	1.25	458	1.00	270	0.50	170	1.00	45	0.25	120	1.25	-	-
26W	55	0.25	-	-	-	-	12	0.02	8	0.05	-	-	88	0.25	-	-
27W	2850	17.50	3000	14.00	8620	19.00	6400	10.50	960	6.25	1550	8.00	1280	3.25	900	2.00
28W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	56	0.10
29W	-	-	-	-	88	0.20	168	0.25	-	-	-	-	15	0.05	-	-
30W	265	1.50	55	0.25	24	0.05	108	0.25	-	-	-	-	-	-	-	-
31W	508	3.25	610	2.75	1150	2.50	1500	2.50	20	0.10	65	0.25	108	0.25	130	0.25
32W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33W	-	-	-	-	10	0.02	-	-	-	-	85	0.50	-	-	-	-
34W	72	0.50	30	0.10	45	0.10	830	1.50	240	1.50	196	1.00	15	0.05	20	0.05
35W	20	0.10	-	-	154	0.50	210	0.50	-	-	-	-	167	0.50	206	0.50
36W	18	0.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37W	280	1.75	404	2.00	1880	4.25	1144	2.00	230	1.50	490	2.50	950	2.50	960	2.25
38W	-	-	-	-	980	2.25	340	0.50	170	1.00	110	0.50	65	0.25	88	0.20
39W	-	-	-	-	-	-	-	-	-	-	40	0.20	-	-	-	-
40W	1000	6.25	690	3.25	1460	3.25	4940	8.00	610	4.00	1010	5.00	975	2.50	820	2.00
41W	-	-	12	0.05	45	0.10	-	-	-	-	-	-	-	-	-	-
42W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40	0.10
43W	-	-	90	0.50	-	-	-	-	-	-	-	-	15	0.05	-	-
44W	-	-	40	0.25	84	0.20	210	0.25	130	0.75	40	0.20	400	1.00	506	1.25
45W	-	-	-	-	250	0.50	180	0.25	-	-	40	0.20	340	1.00	-	-
46W	330	2.00	175	0.75	960	2.00	943	1.50	970	6.00	270	1.50	-	-	250	0.50
47W	78	0.50	144	0.75	285	0.50	720	1.25	-	-	-	-	300	0.75	660	1.50
48W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49W	480	3.00	662	3.00	1175	2.50	510	0.75	233	1.50	250	1.25	130	0.25	52	0.10
50W	730	4.50	1360	6.50	1710	3.75	1620	2.75	240	1.50	192	1.00	2385	6.00	3080	7.00
51W	-	-	-	-	-	-	-	-	48	0.25	38	0.20	475	1.25	620	1.50
52W	-	-	-	-	98	0.20	36	0.05	108	0.75	160	0.75	193	0.50	174	0.50
53W	12	0.05	20	0.10	-	-	10	0.02	-	-	-	-	5	0.01	-	-
54W	260	1.50	85	0.50	15	0.05	28	0.05	-	-	10	0.05	-	-	-	-
55W	-	-	64	0.25	70	0.10	24	0.05	-	-	12	0.05	-	-	-	-
56W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
57W	1360	8.50	720	3.25	2340	5.00	2460	4.00	180	1.00	576	3.00	1134	3.00	2988	7.00
58W	-	-	-	-	-	-	-	-	20	0.10	64	0.25	126	0.25	332	0.75
59W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60W	-	-	-	-	56	0.10	72	0.10	185	1.25	40	0.20	800	2.00	2380	5.50
61W	2030	12.50	1330	6.00	2450	10.00	5450	9.00	190	1.25	1030	5.00	1140	3.00	758	1.75
62W	280	1.75	280	1.25	600	1.50	355	0.50	-	-	280	1.50	182	0.50	188	0.50
63W	-	-	-	-	-	-	-	-	300	2.00	-	-	850	2.20	1960	4.25
64W	75	0.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65W	121	0.75	182	0.75	246	0.50	480	0.75	80	0.50	-	-	520	1.25	690	1.50
66W	64	0.50	36	0.20	230	0.50	117	0.20	-	-	-	-	210	1.50	-	-
67W	-	-	-	-	-	-	42	0.05	-	-	-	-	50	0.10	-	-
68W	36	0.20	85	0.50	262	0.50	162	0.25	-	-	-	-	40	0.10	830	2.00
69W	-	-	-	-	-	-	35	0.05	-	-	-	-	120	0.25	280	0.50
70W	-	-	40	0.25	-	-	-	-	-	-	-	-	-	-	-	-
71W	830	5.00	1120	5.00	1870	3.75	1960	3.25	-	-	466	2.50	630	1.75	840	1.00
72W	-	-	-	-	236	0.50	140	0.25	-	-	-	-	-	-	-	-
73W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
74W	-	-	84	0.50	85	0.20	25	0.05	-	-	-	-	-	-	-	-
75W	-	-	-	-	28	0.05	45	0.05	-	-	-	-	59	0.10	20	0.05
76W	442	2.75	860	4.00	1348	2.00	1395	2.25	-	-	197	1.00	430	1.00	194	0.50
77W	100	0.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
78W	-	-	-	-	-	-	-	-	-	-	-	-	75	0.20	-	-
79W	85	0.50	-	-	578	1.25	-	-	-	-	345	1.75	690	1.75	-	-
80W	-	-	-	-	-	-	420	0.75	-	-	-	-	-	-	-	-
81W	314	2.00	400	1.75	550	1.25	450	0.75	-	-	-	-	245	0.50	-	-
82W	150	1.00	-	-	250	0.50	207	0.25	-	-	-	-	-	-	-	-
83W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85W	215	1.25	330	1.50	700	1.50	770	1.25	-	-	-	-	-	-	-	-
86W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
87W	-	-	-	-	398	1.00	1340	2.25	-	-	-	-	5400	14.00	720	1.50
88W	-	-	-	-	-	-	210	0.25	-	-	-	-	-	-	-	-
89W	1000	6.00	1180	5.50	2470	5.50	4100	6.50	-	-	990	5.00	2100	5.50	4200	9.50
90W	-	-	60	0.05	287	0.50	392	0.50	-	-	-	-	167	0.50	112	0.25
91W	-	-	-	-	-	-	150	0.25	-	-	-	-	-	-	-	-
92W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
93W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
94W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
95W	-	-	360	1.75	1100	2.50	2200	3.50	-	-	-	-	735	2.00	760	1.75
96W	-	-	-	-	900	2.00	225	0.50	-	-	-	-	400	1.00	295	0.75
97W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
98W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
99W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
100W	-	-	2340	10.50	1780	4.00	1680	2.75	-	-	-	-	-	-	600	1.50
101W	-	-	175	0.75	485	1.00	680	1.00	-	-	-	-	-	-	1340	3.00
102W	-	-	-	-	-	-	160	0.25	-	-	-	-	-	-	-	-
Total peak area	16194		21719		44970		61077		15580		19474		38441		43982	

PRA figures were corrected as follows:-

> 5% quoted to nearest 0.5%
0.25 - 5% quoted to nearest 0.25%
< 0.25% quoted as 0.25, 0.2, 0.1, 0.05, 0.02, 0.01

All peak areas corrected to attenuation 1 x 50 and injection volume 4 μl in mm^2

"-" denotes no accurate peak area measurement possible, although trace amount may be present.

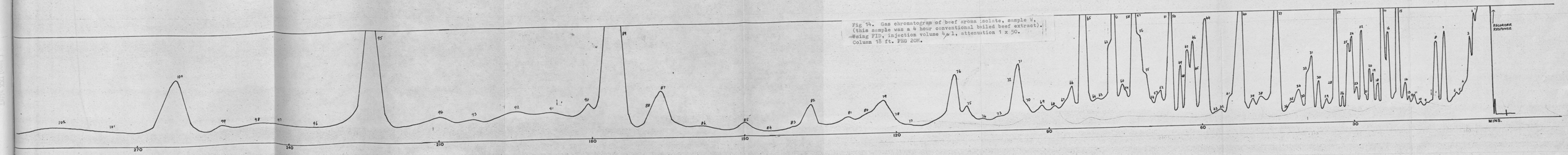


Fig 14. Gas chromatogram of beef aroma isolate, sample W, (this sample was a 4 hour conventional boiled beef extract). Using FID, injection volume 4 µl, attenuation 1 x 50. Column 18 ft. PEG 20M.

Table XXVII

Odour qualities showing significant difference between samples (Figures in brackets after each sample code letter are the total panel scores for that odour quality)

Animal, goaty

E(52), F(45), D(44), I(38), B(34), C(34), O(32), P(29) more intense
H(28), K(27), M(27), A(26), N(22), G(21), J(21), L(15) less intense

Blood like

K(37), M(35), I(33), E(31), C(31), N(29), J(25), D(24), F(21), L(20), B(19), G(18) more intense
P(17), A(17), H(15), O(13) less intense

Bovril like

D(80) more intense
G(52), P(48), B(45), L(43), H(38), O(38), E(37), N(36), F(34), K(32), J(24)
C(21), A(18), M(16), I(12) less intense

Broth like

D(64), L(58), G(56), N(52), P(52), J(50), B(48), C(46) M(45), F(44), K(44), H(43) more intense
E(42), O(40), A(34)
I(15) less intense

Burnt

O(108), F(104) more intense
E(65), P(61), B(48)
G(31), H(22), L(20), N(19), D(18), M(10), C(10), J(8), K(8), A(3)
I(0) less intense

Buttery

D(68), I(60), M(59), A(56), N(51), C(43), L(41), H(41), J(41) more intense
K(35), G(31), B(30), P(25), E(25), F(19), O(15) less intense

Cool, cooling

I(28), C(26), A(21), M(20), B(19), D(18), K(16), G(13), J(13), F(11) more intense
N(10), H(8), E(7), L(6), P(3), O(2) less intense

Flat, dull

I(52), K(37), L(33), C(33), A(30)
H(29), N(27), M(23), D(22), G(13), B(10), J(10), E(9), P(6), O(4) more intense
F(2) less intense

Fragrant

D(28), L(27), G(21)
F(18), H(18), I(18), O(18), N(15), P(11), J(11), A(9), C(9), K(9), B(7), M(6), E(5) more intense
less intense

Meaty boiled

D(120), J(89), K(88), C(87)
A(86), M(79), L(75), G(68), H(67), N(66), F(64), I(64), B(57), P(57) more intense
E(48), O(37) less intense

Meaty roast

D(148), O(125)
P(109), B(100), G(98), F(98), E(87), H(82), L(72), N(71) more intense
K(62), J(56), M(52), C(49), A(37)
I(19) less intense

Oily, fatty

I(60), D(46), J(43), K(40), A(38)
C(32), B(31), L(24), M(23), F(23), E(18), H(11), P(10), O(9), G(9) more intense
N(7) less intense

Paint like

I(17)
M(9), J(7), A(4), K(2), N(1), B(0), C(0), D(0), E(0), F(0), G(0), H(0), L(0), O(0), P(0) more intense
less intense

Rubber burnt

E(12), O(7), F(7)
P(3), K(2), D(2), H(1), C(1), A(0), B(0), G(0), I(0), J(0), L(0), M(0), N(0) more intense
less intense

Savoury

D(104), P(102), G(87), O(83), J(78), B(75), F(73), L(72), N(71)
H(66), K(61), E(58), M(51), C(50), A(39) more intense
I(27) less intense

Sharp, pungent

E(26), D(16)
N(10), F(10), L(8), B(6), C(6), K(6), J(5), O(5), H(4) M(4), P(3), G(2), I(2), A(1) more intense
less intense

Sickly

I(33), M(21)
A(13), K(13), N(11), C(9), B(8), D(8), G(8), H(8), F(7) J(6), L(4), P(4), E(1), O(1) more intense
less intense

Spicy

D(26), H(18)
C(11), P(9), L(8), O(8), K(7), I(6), N(6), A(5), F(5), M(5), B(4), E(4), J(3), G(2) more intense
less intense

Sweet

M(45), D(40), L(38), N(37)
F(27), H(25), O(21), E(20), K(19), G(19), A(17), C(17), I(16), P(15), B(11), J(9) more intense
less intense

Toasted

F(49), O(45), E(42), P(28)
G(22), H(20), N(19), B(14), M(13), J(11), D(12), L(11), K(8), C(6), A(3), I(1) more intense
less intense

Odour strength

F(181), E(180), D(178), O(170), B(156), G(154), P(153) more intense
J(150), N(145), H(140), K(136), M(136), L(131)
C(127), I(126), A(122) less intense

Preference

D(193)
N(161), P(160), G(157), B(153), H(148), L(147), J(145), K(136), F(136), M(134), O(133) A(133) more intense
C(125), E(112)
I(82) less intense

Table XXXI

Correlation coefficients between all odour qualities, odour strength and preference

	Almond like	Ammonia like	Animal, goaty	Aromatic	Blood like	Bovril like	Broth like	Burnt	Buttery	Cool, cooling	Cooked cabbage	Cured meat, bacon	Earthy soil	Flat, dull	Fragrant	Garlic, onion	Herbal, dried herbs hay	Irritating on nose	Marmite like	Meaty raw	Meaty boiled	Meaty roast	Metallic	Musty mouldy	Nasty smelling	Oily, fatty	Paint like	Rancid	Rubber, burnt	Sausage like	Savoury	Sharp, pungent	Sickly	Spicy	Sulphurous	Sweaty	Sweet	Throaty	Toasted	Vegetables, overcooked	Yeasty	Odour strength	Preference
Almond like		0.3050	0.1058	-0.2881	0.6267	-0.4171	-0.3096	-0.5540	0.6728	0.6744	0.2697	0.1971	0.2894	0.5861	-0.0777	-0.2983	0.2657	0.4305	-0.0223	0.6504	0.4815	-0.5512	0.3626	0.4094	0.5589	0.6920	0.7195	0.5255	-0.2406	0.2059	-0.5495	-0.0296	0.7349	0.0697	0.1122	0.6140	0.3158	0.2011	-0.5651	0.3154	0.0188	-0.4318	-0.4271
Ammonia like			0.6954	-0.5155	0.2592	-0.0837	-0.3707	0.0244	0.0643	0.2836	-0.1787	0.3549	0.4358	0.0576	-0.3637	-0.0404	-0.0345	0.4831	0.2514	0.2791	-0.1172	-0.1396	0.0722	0.1769	0.5152	0.3337	0.2575	0.4535	0.4602	0.4631	-0.3520	0.5547	0.0162	0.2514	0.5637	0.3449	0.1503	0.3670	0.4790	0.3911	0.1349	0.6302	-0.2062
Animal, goaty				-0.1737	0.1263	0.2639	-0.1703	0.4545	-0.2184	0.1762	-0.0718	0.0967	0.5425	-0.2202	-0.0030	-0.1328	-0.0038	0.5994	0.4307	0.1203	-0.0722	0.3022	0.2566	0.4827	0.5016	0.1993	-0.0331	0.1681	0.6901	0.4082	0.0156	0.6290	0.3713	0.7130										
Aromatic					-0.2557	0.6713	0.7102	0.0862	0.0328	-0.2216	0.0991	-0.3289	-0.1219	-0.2664	0.7705	0.0965	0.4359	-0.1342	0.3619	-0.2926	0.2720	0.5853	0.2006	-0.0734	-0.5680	-0.2509	-0.3949	-0.5809	-0.1335	0.0788	0.6603	0.1006	-0.2846	0.2915	-0.4513	-0.0937	0.3560	0.2156	0.1615	0.1255	0.3001	0.6772	0.7766
Blood like						-0.3344	-0.1959	-0.4392	0.3402	0.5048	0.5769	0.3676	0.2671	0.3718	-0.3558	-0.1230	0.0320	0.4571	-0.0270	0.6554	0.3200	-0.4973	0.3690	0.1411	0.5224	0.4255	0.4000	0.3663	-0.0267	0.2205	-0.4674	0.2695	-0.4356	0.5181	-0.0712	0.1253	0.2063	0.2512	0.3890	0.0980	0.3185	0.3455	0.1632	0.3455	0.8862
Bovril like							0.7323	0.2862	-0.0771	-0.3958	-0.2835	-0.2334	-0.0350	-0.3908	0.6698	0.0733	0.2339	0.2556	0.6928	-0.5512	0.1486	0.8984	0.3977	-0.0868	-0.5370	-0.2231	-0.5932	-0.5800	0.2000	0.3544	0.8600	0.4246	-0.5443	0.4339	-0.4681	0.2104	0.3999	0.2894	0.1418	0.3455	0.1632	0.3455	0.8862
Broth like								0.0130	0.0612	-0.3182	0.2461	-0.0763	-0.1097	0.3659	0.5730	0.0690	0.1753	0.0406	0.5788	0.5946	0.4014	0.6338	0.2750	-0.3125	-0.7561	-0.3279	-0.4498	-0.7854	-0.0981	0.2507	0.7646	0.2825	-0.5925	-0.1332	0.2169	-0.3491	-0.2115	0.2891	0.9416	0.1849	0.2909	0.7694	0.0179
Burnt									-0.8310	-0.5227	-0.1479	-0.0905	0.0172	-0.7884	0.0412	0.0911	-0.3688	-0.0956	0.1268	-0.4159	-0.6501	0.6141	-0.2442	0.3792	-0.0089	-0.5234	-0.4356	-0.3825	0.7308	0.1048	0.4123	0.2793	-0.6468	0.3808	-0.2482	0.5284	0.5378	-0.0141	-0.7738	0.0245	-0.1596	-0.5375	0.1325
Buttery										0.4875	0.0928	-0.0408	0.1391	0.7519	0.2362	-0.1887	0.4313	0.3206	0.2422	0.2344	0.7155	-0.3641	0.3351	0.1162	0.5373	0.7016	0.4897	0.6717	-0.4083	-0.1467	-0.5964	-0.2160	0.7189	-0.0081	-0.0731	0.4098	-0.0986	-0.1542	-0.6258	0.2786	-0.3362	-0.4667	-0.3545
Cool, cooling											0.3012	0.2781	0.3953	0.5682	-0.1982	-0.4564	0.5215	0.1069	-0.0528	0.6991	0.4902	-0.5732	0.2383	0.1861	0.1267	-0.1237	-0.1003	-0.2733	-0.0425	-0.0334	-0.1761	0.1291	-0.0512	-0.1161	0.3482	0.2505	-0.0536	0.2298	-0.2006	0.4376	-0.4123	-0.2686	-0.4102
Cooked cabbage												0.0709	0.1563	-0.0926	-0.2594	-0.1187	-0.1574	0.1374	0.0658	0.1653	0.3223	-0.2108	0.2056	-0.2029	0.0882	0.1402	-0.0842	0.2919	0.1135	0.5015	-0.3858	0.2846	0.0900	0.0141	0.2044	0.3954	-0.0699	0.3815	0.0006	0.4749	-0.4966	0.1984	-0.1311
Cured meat, bacon													0.1126	0.2406	-0.1675	0.1497	0.2371	0.0548	-0.1373	0.2930	-0.0790	-0.2880	-0.1728	0.1371	0.4987	0.5271	0.0451	0.3167	0.2978	0.2160	-0.2255	0.4655	0.7279	0.2116	-0.0348	0.3074	0.2191	-0.1693	-0.8353	-0.1769	-0.2391	0.2751	0.5896
Earthy, soil														0.1176	0.0092	0.1325	0.3402	0.4779	0.2499	0.3634	0.4375	-0.1391	0.2216	-0.1145	0.2133	0.5758	0.4762	0.6252	-0.5286	-0.0526	-0.6843	-0.2815	-0.1392	0.6362	-0.3767	0.0010	0.4634	0.2597	0.0754	0.1205	0.2916	0.2916	0.0233	-0.0302
Flat, dull															0.0351	0.0520	0.4784	0.1904	-0.2584	0.5380	0.4573	-0.6473	0.1337	0.0044	-0.5137	-0.0025	-0.2626	-0.3774	-0.1141	0.2655	0.5707	0.1412	-0.4926	-0.0243	0.2956	0.0318	0.0541	0.3496	0.1254	-0.0914	-0.2228	-0.1978	0.1357
Fragrant																0.0956	0.5641	0.1003	0.3948	-0.2920	0.3671	0.5524	0.1820	-0.1701	-0.1784	-0.2557	-0.4423	-0.1610	0.4198	0.3773	0.0308	0.3389	0.2656	0.2346	-0.2215	0.1871	0.0564	-0.0206	-0.4521	0.1705	-0.2801	-0.2607	-0.0155
Garlic, onion																	0.0377	0.1397	-0.1649	-0.0789	-0.1092	0.0811	-0.0038	-0.2022	-0.0674	0.4974	0.0415	0.3134	-0.3573	0.1538	-0.0241	-0.0464	0.1891	0.4489	0.4942	0.7617	0.4005	0.6426	0.0067	0.3392	0.0975	0.5596	0.6250
Herbal, dried herbs, hay																		-0.0211	0.1274	0.3673	0.5290	-0.0494	0.1978	0.4143	0.3707	0.3596	0.0262	0.0376	0.4003	0.6126	-0.0648	0.6732	-0.2053	0.5652	-0.0738	0.4709	0.3221	0.3772	0.2361	0.4449	0.0475	-0.4192	-0.7071
Irritating on nose																			0.4308	0.1510	0.3713	0.1449	0.6732	0.1775	-0.3145	-0.0000	-0.3004	-0.3731	0.1766	0.2410	0.5771	0.5077	0.9761	-0.3847	0.3439	0.1932	-0.1870	-0.0319	-0.4748	0.0605	-0.1959	-0.2476	0.3936
Marmite like																				-0.4904	0.3784	0.6329	0.4732	0.1123	0.7769	0.6576	0.6468	0.7731	-0.1114	0.0800	-0.7224	-0.0705	0.3060	0.5030	-0.4377	0.5529	0.3346	0.1409	-0.5832	0.3065	-0.2532	0.8097	0.6881
Meaty raw																					0.1722	-0.7195	0.0995	-0.1253	-0.0465	0.5892	0.0832	0.0741	-0.4600	0.0054	0.0326	0.0266	-0.6132	0.4331	-0.0587	-0.0355	0.1432	0.3145	0.6640	0.1227	0.4211	0.1587	0.2894
Meaty boiled																						-0.1265	0.5915	0.1511	-0.5110	-0.4379	-0.6569	-0.6952	0.3966	0.2627	0.8871	0.3667	0.1810	0.4433	0.0792	0.6604	0.2118	0.3665	-0.2024	0.2060	0.1072	0.2973	-0.2784
Meaty roast																							0.2730	0.3183	0.1673	0.4516	-0.0244	0.0022	0.0222	0.2468	0.2117	0.2210	0.2594	0.1263	0.2309	0.2987	0.2921	0.4975	0.3220	0.3188	0.4324	-0.0684	-0.7712
Metallic																									0.4861	0.0708	0.2808	0.0400	0.3995	0.1223	-0.1301	0.1236	0.5506	-0.3519	0.5458	0.2160	-0.3024	0.0854	-0.0817	0.0992	-0.0891	-0.3157	-0.3004
Musty, mouldy																										0.5754	0.6089	0.7036	0.2711	0.0415	-0.6562	0.0737	0.6264	0.0995	0.1276	0.3176	-0.1808	-0.0950	-0.6159	0.0349	-0.3700	-0.4281	-0.5922
Nasty smelling																											0.6152	0.7591	-0.2947	0.0352	-0.3864	-0.0736	0.8044	-0.2479	0.1637	-0.0136	-0.0715	-0.2886	-0.4687	-0.2274	0.0228	-0.4853	-0.7374
Oily, fatty																												0.7124	-0.3248	-0.2165	-0.5663	-0.3297	0.6693	-0.2376	0.3512	0.0202	-0.4690	-0.3642	-0.5199	-0.2046	-0.4285	0.7119	-0.2351
Paint like																													-0.1714	-0.1514	-0.7158	0.2547	-0.4960	-0.0494	0.6746	0.1082	-0.1446	0.5470	0.7902	0.2969	0.2024	0.3199	-0.0648
Rancid																														0.5184	0.1353	0.7062	-0.2380	0.1974	0.5904	0.5192	0.3188	0.6628	0.1703	0.4181	0.1736	0.6777	0.8226
Rubber, burnt																															0.0708	0.7880	-0.6938	0.3460	-0.3082	-0.1682	0.0893	0.1093	0.5145	0.0361	0.3798	0.6133	0.0777
Sausage like																																0.1840	-0.3547	0.1833	0.5909	0.4622	0.2369	0.7172	0.4243	0.5117	0.0083	0.3700	-0.5442	-0.4140
Savoury																																		-0.0103	0.0118	0.2441	0.1567	-0.2169	-0.6324	-0.1220	-0.0119	0.1367	0.4767
Sharp, pungent																																			-0.2452	0.3620	0.4044	0.1871	-0.0573	0.1223	0.2340	0.2629	-0.5872
Sickly																																				0.1950	-0.2347	0.2732	0.2335	-0.0285	-0.0016	-0.0436	0.0456
Spicy																																					0.4887	0.5667	-0.2621	0.5910	-0.0177	-0.0615	0.3525
Sulphurous																																						0.6084	-0.1065	0.3755	0.2031			
Sweaty																																							0.3392	0.7248	0.1156	0.4096	0.0845
Sweet																																								0.1987	0.4232	0.8593	0.1254
Throaty																																									-0.0683	0.2676	0.0675
Toasted																																										0.3724	0.1277
Vegetables, overcooked																																											0.3482
Yeasty																																											
Odour strength																																											
Preference																																											

Fig 23a Selected peak variations for samples of extraction time 15 min (sample B, conventional and sample J microwave).

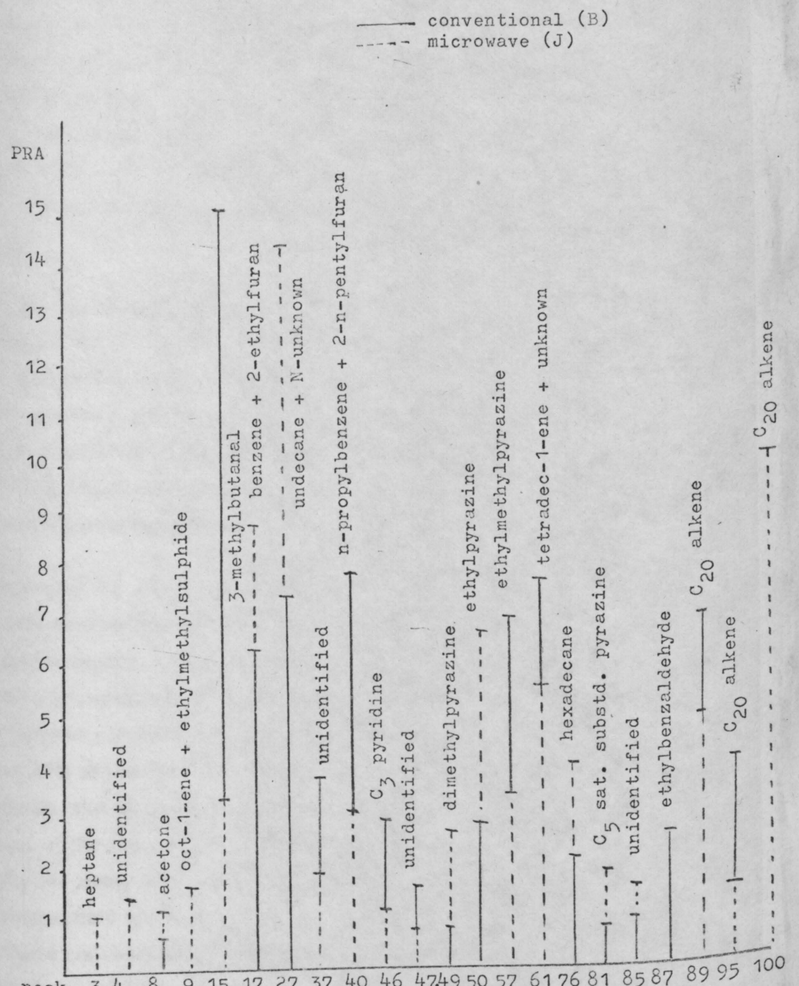


Fig 23b Selected peak variations for samples extracted for 30 min (sample C, conventional and sample K, microwave).

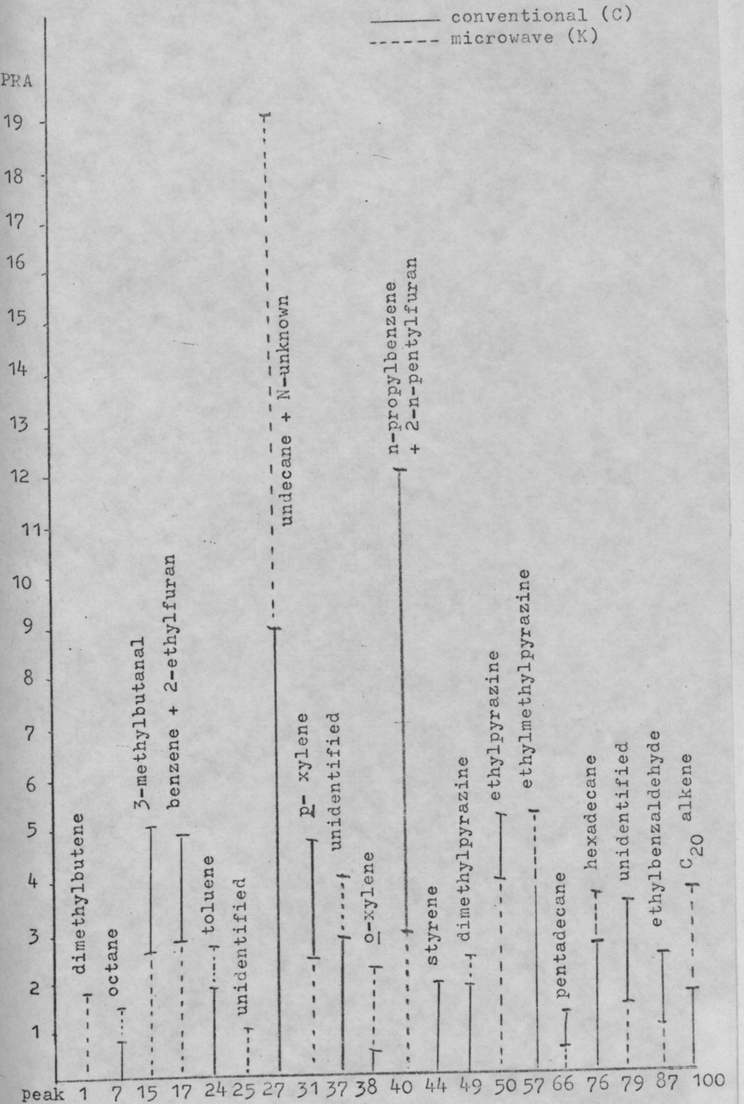


Fig 23c Selected peak variations for samples extracted for 1 hour (sample D, conventional and sample L, microwave).

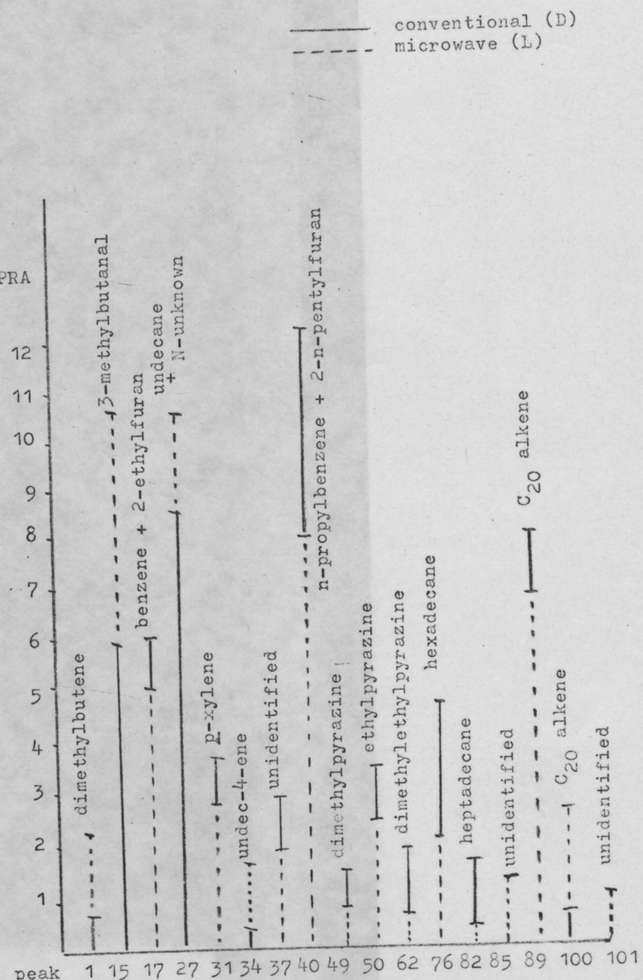


Fig 24. Comparison of the effect of heating time on various classes of aroma compounds produced by conventional boiling and roasting of beef (corrections made for volatiles lost during 60 min boil off for the conventional roast beef).

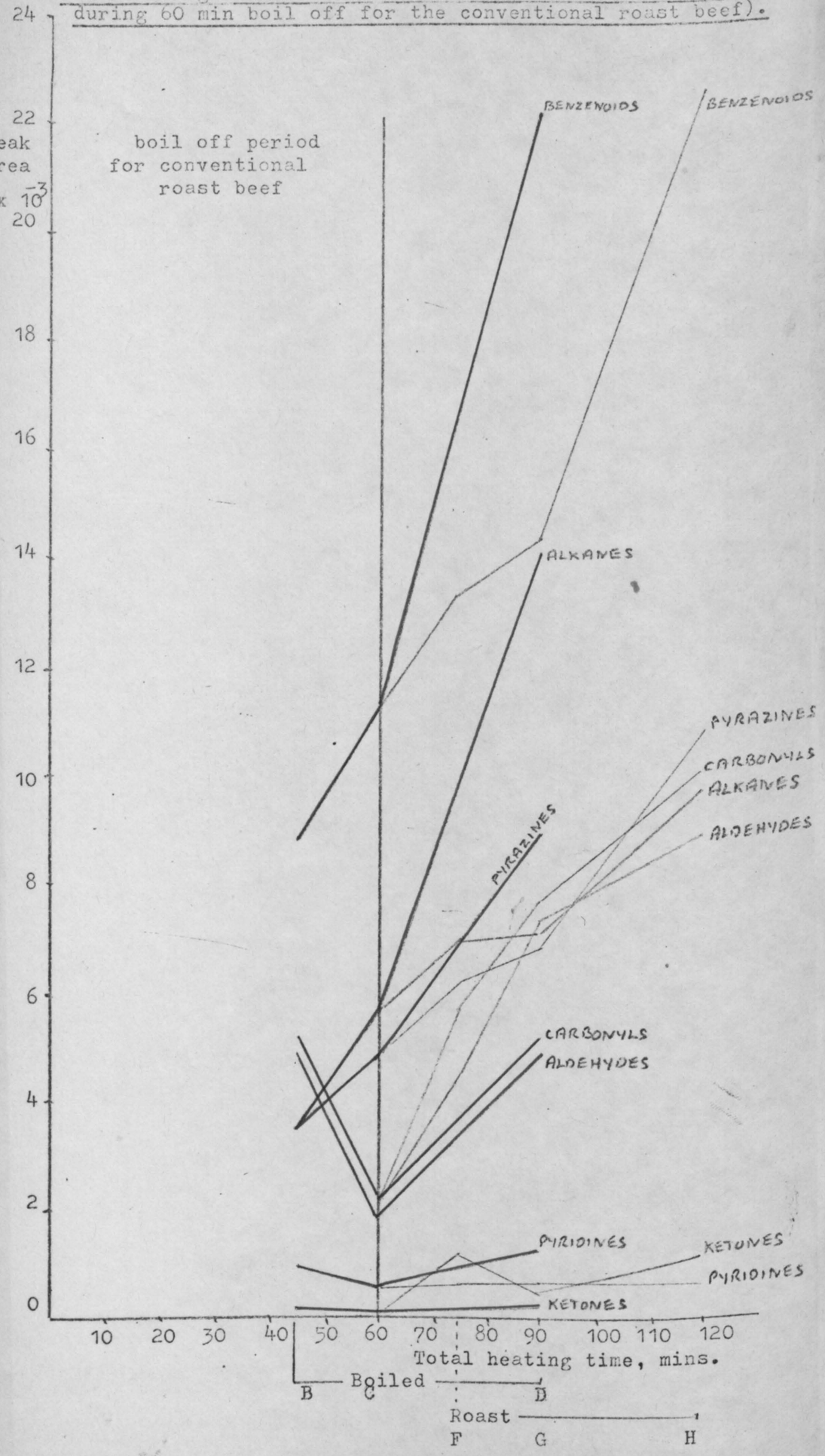


Fig 24 continued:-

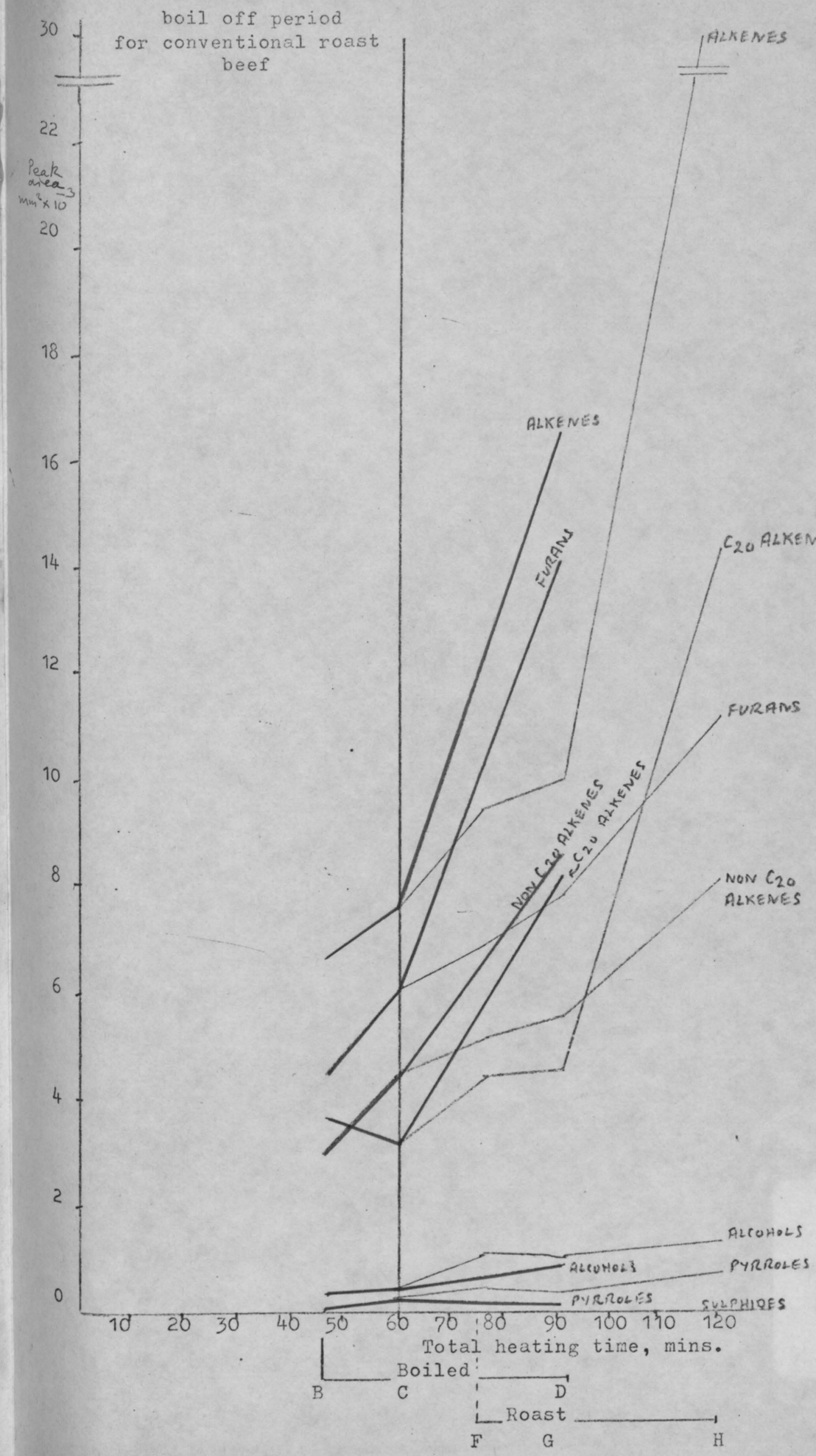


Fig 25. Comparison of the effect of heating time on various classes of aroma compounds produced by microwave boiling and roasting of beef (corrections made for volatiles lost during 20 min. boil off for the microwave roast beef).

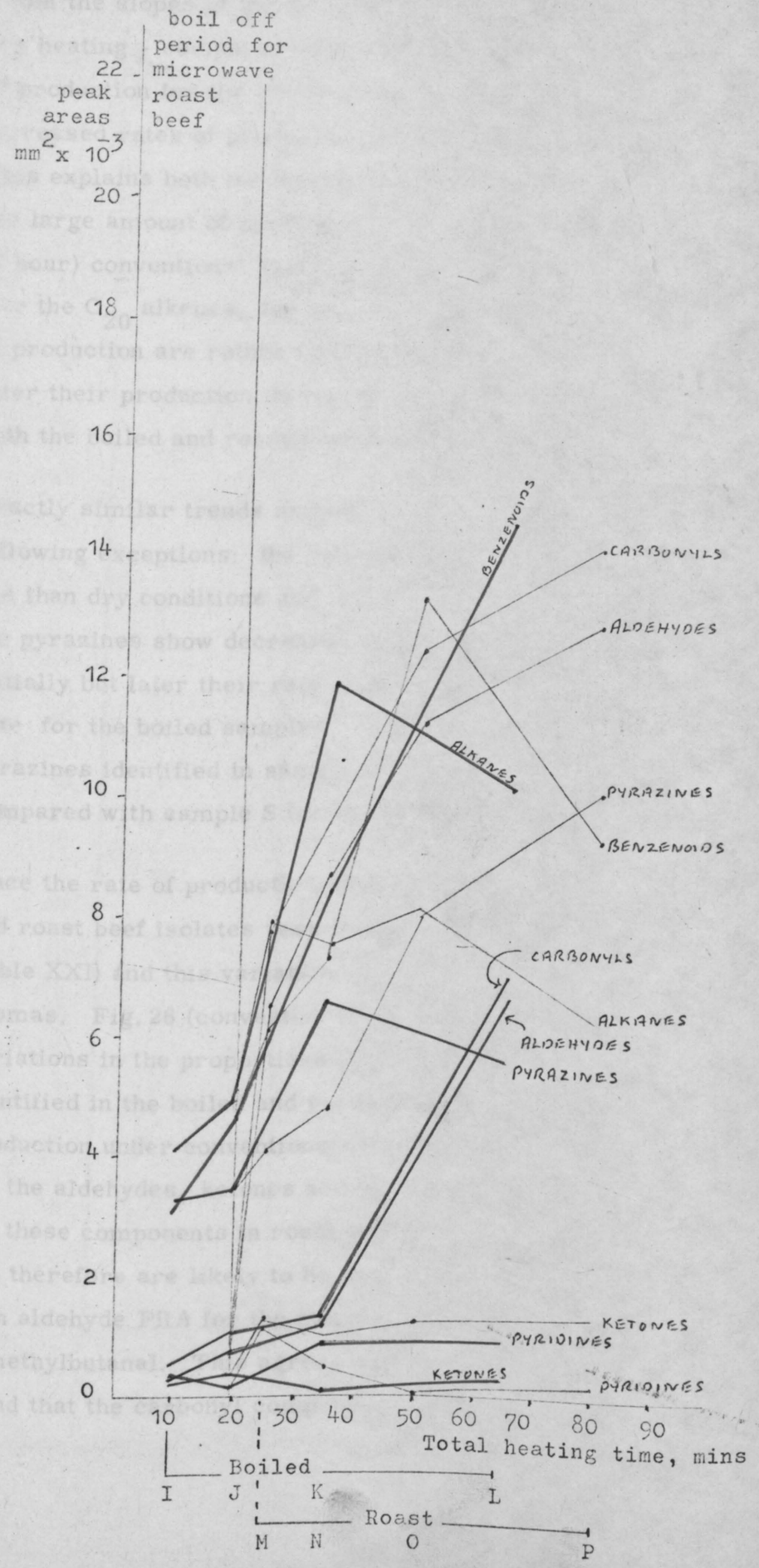


Fig 25 continued:-

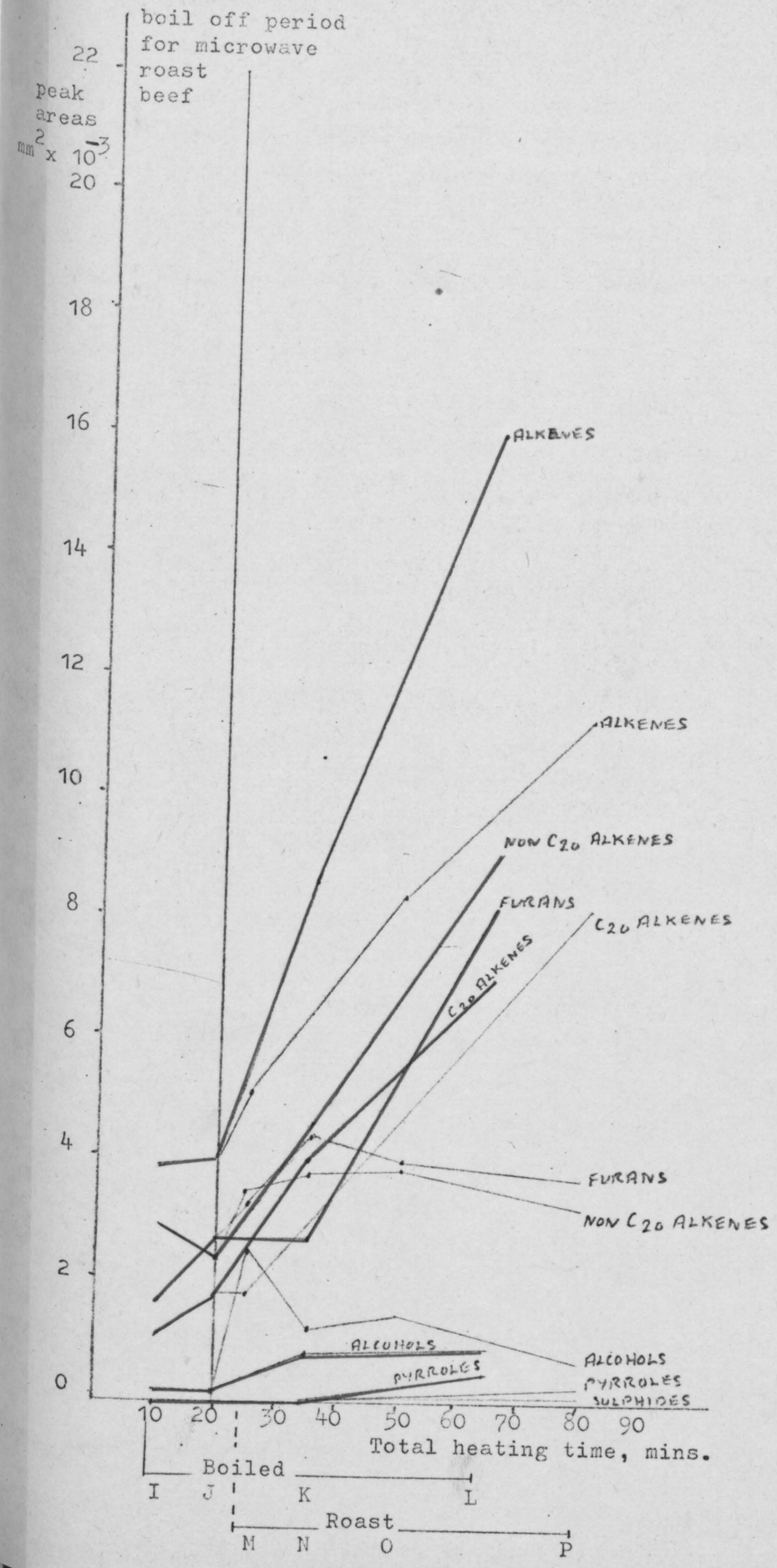


Table XXXV

Odour qualities showing trends to increase or decrease within each series of samples (A-D, E-H, I-L and M-P) as total actual scores and as total scores expressed as a percentage of total panel scores.

Samples A-D (conventionally boiled beef samples)	
Odour qualities which increase with heating time	
Total score	% score
animal, goaty	aromatic
aromatic	Bovril like
Bovril like	broth like
broth like	burnt
burnt	fragrant
fragrant	Marmite like
Marmite like	meaty boiled
meaty boiled	meaty roast
meaty roast	savoury
savoury	sharp, pungent
sharp, pungent	spicy
spicy	sweet
sweet	throaty
throaty	yeasty
toasted	
vegetables, overcooked	
yeasty	
and odour strength	
and preference	
Odour qualities which decrease with heating time	
Total score	% score
meaty raw	irritating on nose
nasty smelling	meaty raw
paint like	metallic
rancid	nasty smelling
	oily, fatty
	paint like
	rancid
	sickly

Samples E-H (conventionally roasted beef samples)	
Odour qualities which increase with heating time	
Total score	% score
aromatic	aromatic
buttery	broth like
flat, dull	buttery
fragrant	flat, dull
meaty boiled	fragrant
sickly	meaty boiled
spicy	meaty roast
and preference	savoury
	sickly
	spicy
	sweet
	yeasty
Odour qualities which decrease with heating time	
almond like	almond like
ammonia like	ammonia like
animal, goaty	animal, goaty
blood like	blood like
cured meat, bacon	cured meat, bacon
earthy, soil	earthy, soil
nasty smelling	nasty smelling
oily, fatty	oily, fatty
rancid	rancid
rubber, burnt	rubber, burnt
sausage like	sausage like
sharp, pungent	sharp, pungent
sweaty	throaty
throaty	toasted
toasted	vegetables, overcooked
vegetables, overcooked	
and odour strength	

Table XXXV

Odour qualities showing trends to increase or decrease within each series of samples (A-D, E-H, I-L and M-P) as total actual scores and as total scores expressed as a percentage of total panel scores.

Samples A-D (conventionally boiled beef samples)	
Odour qualities which increase with heating time	
Total score	% score
animal, goaty	aromatic
aromatic	Bovril like
Bovril like	broth like
broth like	burnt
burnt	fragrant
fragrant	Marmite like
Marmite like	meaty boiled
meaty boiled	meaty roast
meaty roast	savoury
savoury	sharp, pungent
sharp, pungent	spicy
spicy	sweet
sweet	throaty
throaty	yeasty
toasted	
vegetables, overcooked	
yeasty	
and odour strength	
and preference	
Odour qualities which decrease with heating time	
Total score	% score
meaty raw	irritating on nose
nasty smelling	meaty raw
paint like	metallic
rancid	nasty smelling
	oily, fatty
	paint like
	rancid
	sickly

Samples E-H (conventionally roasted beef samples)	
Odour qualities which increase with heating time	
Total score	% score
aromatic	aromatic
buttery	broth like
flat, dull	buttery
fragrant	flat, dull
meaty boiled	fragrant
sickly	meaty boiled
spicy	meaty roast
and preference	savoury
	sickly
	spicy
	sweet
	yeasty
Odour qualities which decrease with heating time	
almond like	almond like
ammonia like	ammonia like
animal, goaty	animal, goaty
blood like	blood like
cured meat, bacon	cured meat, bacon
earthy, soil	earthy, soil
nasty smelling	nasty smelling
oily, fatty	oily, fatty
rancid	rancid
rubber, burnt	rubber, burnt
sausage like	sausage like
sharp, pungent	sharp, pungent
sweaty	throaty
throaty	toasted
toasted	vegetables, overcooked
vegetables, overcooked	
and odour strength	

Samples I-L (microwave boiled beef samples)	
Odour qualities which increase with heating time	
Total score	% score
aromatic	aromatic
Bovril like	Bovril like
broth like	broth like
burnt	burnt
garlic, onion	garlic, onion
meaty roast	meaty roast
sausage like	sausage like
savoury	savoury
sharp, pungent	sharp, pungent
spicy	spicy
sweet	sweet
throaty	throaty
vegetables, overcooked	vegetables, overcooked
and preference	
Odour qualities with decrease with heating time	
Total score	% score
almond like	almond like
ammonia like	ammonia like
buttery	animal, goaty
cool, cooling	buttery
musty, mouldy	cool, cooling
meaty raw	musty, mouldy
nasty smelling	meaty raw
oily, fatty	nasty smelling
paint like	oily, fatty
rancid	paint like
sickly	rancid
and odour strength	sickly

Samples M-P (microwave roasted beef samples)	
Odour qualities which increase with heating time	
Total score	% score
Bovril like	Bovril like
burnt	burnt
meaty roast	meaty roast
savoury	savoury
spicy	spicy
toasted	toasted
and odour strength	
Odour qualities which decrease with heating time	
Total score	% score
almond like	almond like
blood like	blood like
buttery	buttery
cool, cooling	cool, cooling
cooked cabbage	cooked cabbage
flat, dull	flat, dull
meaty raw	meaty raw
paint like	paint like
sickly	sickly
sweet	sweet
throaty	throaty
vegetables, overcooked	vegetables, overcooked

Table XXXVII

Peak areas and percent relative abundances of components of aged beef aroma

	Time of ageing							
	0 weeks		2 weeks		3 weeks		4 weeks	
	Area	%	Area	%	Area	%	Area	%
1W	-	-	-	-	-	-	-	-
2W	-	-	-	-	-	-	-	-
3W	245	1.50	-	-	243	1.00	296	0.75
4W	-	-	-	-	-	-	-	-
5W	-	-	-	-	-	-	-	-
6W	-	-	-	-	-	-	-	-
7W	216	1.50	220	1.00	110	0.50	210	0.50
8W	110	0.75	85	0.50	190	0.75	105	0.25
9W	-	-	-	-	-	-	10	0.02
10W	-	-	-	-	-	-	-	-
11W	-	-	-	-	-	-	-	-
12W	-	-	-	-	-	-	-	-
13W	10	0.05	10	0.05	365	1.50	1280	3.00
14W	15	0.10	10	0.05	25	1.00	40	0.10
15W	650	4.00	1870	9.00	1580	6.50	2620	6.00
16W	-	-	-	-	25	1.00	40	0.10
17W	365	2.25	300	1.50	280	1.25	860	2.00
18W	40	0.25	5	0.02	15	0.05	60	0.10
19W	95	0.50	110	0.50	70	2.75	150	0.50
20W	100	0.50	100	0.50	305	1.25	670	1.50
21W	-	-	10	0.05	-	-	-	-
22W	95	0.50	175	0.75	155	0.50	185	0.50
23W	5	0.02	70	0.25	30	0.10	60	0.10
24W	40	0.25	-	-	60	0.25	50	0.10
25W	1280	8.00	2270	10.50	1380	5.50	2280	5.00
26W	5	0.02	5	0.02	20	0.10	-	-
27W	410	2.50	600	2.75	520	2.00	1480	3.50
28W	-	-	15	0.05	-	-	-	-
29W	30	0.20	-	-	30	0.10	65	0.10
30W	30	0.20	-	-	30	0.10	60	0.10
31W	128	0.75	150	0.75	75	0.25	320	0.75
32W	-	-	15	0.05	-	-	-	-
33W	40	0.25	15	0.05	30	0.10	56	0.10
34W	10	0.05	-	-	30	0.10	30	0.05
35W	-	-	-	-	30	0.10	220	0.50
36W	-	-	-	-	-	-	-	-
37W	330	2.00	400	2.00	690	2.75	920	2.00
38W	-	-	20	0.10	30	0.10	75	1.75
39W	-	-	-	-	10	0.05	30	0.05
40W	270	1.75	365	1.75	290	1.25	1280	3.00
41W	-	-	-	-	-	-	-	-
42W	-	-	-	-	-	-	-	-
43W	-	-	-	-	-	-	-	-
44W	-	-	-	-	70	0.25	222	0.50
45W	-	-	-	-	10	0.05	55	0.10
46W	20	0.10	20	0.10	20	0.10	525	1.25
47W	315	2.00	336	1.50	200	1.00	640	1.50
48W	25	0.10	10	0.05	80	0.25	200	0.50
49W	80	0.50	100	0.50	120	0.50	184	0.50
50W	200	1.25	140	0.75	175	0.75	780	1.75
51W	-	-	-	-	10	0.05	130	0.25
52W	-	-	-	-	-	-	-	-
53W	-	-	-	-	-	-	-	-
54W	-	-	-	-	-	-	-	-
55W	-	-	-	-	-	-	-	-
56W	30	0.25	-	-	80	0.25	95	0.20
57W	1030	6.50	1200	5.50	1120	4.50	2580	5.50
58W	-	-	-	-	-	-	-	-
59W	-	-	-	-	-	-	-	-
60W	95	0.50	130	0.50	180	0.75	280	0.50
61W	355	2.25	210	1.00	320	1.25	1070	2.50
62W	200	1.25	200	1.00	150	0.50	670	1.50
63W	-	-	-	-	20	0.10	50	0.10
64W	-	-	-	-	-	-	-	-
65W	60	0.25	-	-	160	0.50	280	0.50
66W	100	0.50	220	1.00	310	1.25	660	1.50
67W	-	-	-	-	-	-	-	-
68W	80	0.50	70	0.25	85	0.25	195	0.50
69W	-	-	-	-	-	-	-	-
70W	-	-	-	-	-	-	-	-
71W	600	3.70	700	3.25	240	1.00	1150	2.50
72W	-	-	-	-	480	2.00	230	0.50
73W	-	-	-	-	-	-	130	0.25
74W	-	-	-	-	-	-	-	-
75W	-	-	-	-	-	-	-	-
76W	75	0.50	75	0.25	120	0.50	400	1.00
77W	100	0.50	-	-	100	0.50	-	-
78W	-	-	-	-	-	-	-	-
79W	430	2.75	730	3.50	600	2.50	1650	3.75
80W	-	-	-	-	-	-	-	-
81W	-	-	-	-	-	-	180	0.50
82W	160	1.00	280	1.25	200	1.00	360	0.75
83W	-	-	-	-	-	-	-	-
84W	-	-	-	-	-	-	-	-
85W	-	-	-	-	-	-	-	-
86W	-	-	160	0.75	-	-	-	-
87W	300	1.75	230	1.00	450	2.00	810	2.00
88W	-	-	-	-	-	-	-	-
89W	5400	33.00	7400	34.50	9200	37.00	12700	28.00
90W	300	2.00	180	1.00	600	2.50	750	1.75
91W	-	-	-	-	-	-	-	-
92W	-	-	-	-	-	-	-	-
93W	-	-	-	-	-	-	-	-
94W	-	-	-	-	-	-	-	-
95W	1740	11.00	2250	10.50	2950	12.00	4500	10.00
96W	-	-	-	-	-	-	-	-
97W	-	-	-	-	-	-	-	-
98W	-	-	-	-	-	-	-	-
99W	-	-	-	-	-	-	-	-
100W	-	-	-	-	-	-	-	-
101W	-	-	-	-	-	-	-	-
102W	-	-	-	-	-	-	-	-
Total Peak Area mm^2	16214		21461		24688		44978	

4µl at 1 x 50

See notes at foot of Table XXI, p. 106.

Table XL

Components of beef aroma isolate (sample W) grouped into different classes of chemical compounds.

n-Alkanes

3W n-heptane
6W 2-methylheptane
7W n-octane
13W n-nonane
(20W) n-decane
(27W) n-undecane
(56W) n-tetradecane
66W n-pentadecane
76W n-hexadecane
82W n-heptadecane

Alkenes

1W dimethylbutene
2W hex-1-ene
5W hept-1-ene
(9W) oct-1-ene
16W non-1-ene
23W dec-1-ene
30W undec-1-ene
34W undec-4-ene
43W dodec-1-ene
48W tridec-1-ene
(61W) tetradec-1-ene
77W hexadec-1-ene
89W C_{20} alkene
95W C_{20} alkene
100W C_{20} alkadiene

Aliphatic ketones

8W acetone
14W butanone
19W 2-pentanone

Aliphatic aldehydes

15W 3-methylbutanal
29W n-hexanal

(Carbonyls = aliphatic aldehydes + aliphatic ketones)

Aliphatic alcohols

(20W) a methylbutanol
72W nonanol

Sulphides

(9W) ethylmethylsulphide
28W dimethyldisulphide

Furans

11W 2-methylfuran
(17W) 2-ethylfuran
(40W) 2-pentylfuran

Benzenoids

(17W) benzene
24W toluene
31W p-xylene
38W o-xylene
(40W) n-propylbenzene
42W a C_3 benzene
44W styrene
71W benzaldehyde
83W phenol
84W m-tolunitrile
87W ethylbenzaldehyde

Pyridines

39W a methylpyridine (prob. 2-methyl)
46W a C_3 pyridine (prob. n-propyl)

Pyrazines

45W methylpyrazine
49W a dimethylpyrazine (prob. 2,6-)
50W ethylpyrazine
57W ethylmethylpyrazine (prob. 2-ethyl-6-methyl)
58W an ethylmethylpyrazine (prob. 2-ethyl-5-methyl)
59W a trimethylpyrazine (prob. 2,3,5-)
62W a dimethylethylpyrazine (prob. 2,3-dimethyl-5-ethyl)
64W a dimethylethylpyrazine (prob. 2,5-dimethyl-3-ethyl)
81W a C_5 satd. substd. pyrazine (prob. methylisobutyl)

Pyrroles

69W pyrrole
73W a methylpyrrole (prob. 2-methyl)
80W a dimethylpyrrole (2,4- or 2,5-)

N.B. Brackets indicate composite peaks